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REPORT OF ACTIVITIES September-October 1991

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LABORATORIES & DIVISIONS

Antarctic Ecosystem Research Group, Chief ..... *Rennie Holt*
La Jolla, California
Coastal Fisheries Resources Division, Chief ..... *John R. Hunter*
La Jolla, California
Marine Mammal Division, Chief ..... *Douglas P. DeMaster*
La Jolla, California
Honolulu Laboratory, Director ..... *George W. Boehlert*
Honolulu, Hawaii
Pacific Fisheries Environmental Group, Chief ..... *Andrew Bakun*
Monterey, California
Pelagic Fisheries Resources Division, Chief ..... *Gary T. Sakagawa*
La Jolla, California
Tiburon Laboratory, Director ..... *Alec MacCall*
Tiburon, California

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ANTARCTIC ECOSYSTEM RESEARCH GROUP

La Jolla, California

Report of CCAMLR X Scientific Committee and Commission Meetings

The Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) Working Group on Fish Stock Assessment, the CCAMLR Scientific Committee (SC), and the Tenth Meeting of the CCAMLR Commission met in Hobart, Tasmania, Australia, between October 8 and November 1, 1991. Rennie Holt, George Watters, and Larry Jacobson, SWFSC, attended the Fish Stock meeting. Scientific advisers at the Scientific Committee and/or Commission meetings were Holt (Head of Scientific Delegation), John Bengtson (National Marine Mammal Laboratory), Marc Mangel (University of California, Davis), Beth Marks (Yale University), and Watters.

Finfish Resources

Most of the finfish catch was taken by the Soviet Union in subarea 48.3 (South Georgia Island). Fishing for finfish during the 1991 (1990/91 split year) season was prohibited in subareas 48.1 (Antarctic Peninsula) and 48.2 (South Orkney Islands). Total fish catches for the 1991 season in all areas in metric tons (t) are *Champsocephalus gunnari*, 13,375 t; *Dissostichus eleginoides*, 5,585 t; *Notothenia gibberifrons*, 3 t; *N. rossii*, 287 t; *Electrona carlsbergi*, 78,488 t; and a total for all species of 98,610 t. Although a total allowable catch (TAC) limit for the 1991 season in subarea 48.3 for *C. gunnari* was set at 26,000 t, only 93 t were taken and most of this was in research vessel catches. The remaining 13,282 t of the 1991 catch was taken in subarea 58.5 (Indian Ocean area) by Soviet and French vessels. Because the *E. carlsbergi* catch increased (23,623 t in 1990) during the 1991 season, the total fish catch increased substantially (from 47,727 t caught in the 1990 season).

Krill Resources

The total commercial krill catch during the 1991 season was 357,538 t. This is slightly below the 374,775 t caught in the 1990 season. The Commission noted that the SC agrees there is a critical need for a solution to krill mortality occurring when the krill are not retained in the trawls during the fishing process. The Commission also generally endorsed the following ideas:

1. Length frequency data from the commercial fishery within fine-scale reporting areas should be submitted to the Secretariat even though the collection of such data may, to a large extent, only be possible by specially trained personnel.

2. Haul-by-haul data from the commercial fishery should be collected and submitted to the Secretariat. As a priority, these data should be submitted for areas within 100 km of land-based predator colonies and Conservation of Antarctic Marine Living Resources (CCAMLR) Ecosystem Monitoring Program sites.

The Commission endorsed the advice of the SC that reactive management of the krill fishery (the practice of taking management action when the need for it has become apparent) is not a viable long-term strategy. Some form of feedback management, which involves the continuous adjustment of management measures in response to information, is preferred as a long-term strategy. In the interim, a precautionary approach is desirable and, in particular, a precautionary limit on annual catches should be considered.

The Commission noted that all members presently fishing for krill expect their fishing to stay at current levels in the coming season and the disposition of the fishing effort to generally follow historical patterns.

The SC advised the Commission that, for Statistical Area 48, an annual catch limit of 1.5 million t (based on estimates of potential yield) was the best available scientific advice on a precautionary catch limit. However, the SC noted the following: 1) the limit must be divided into subareas to allow for the possible interaction between krill populations in the subareas, 2) the limit must ensure that the catch is not entirely concentrated in the foraging range of vulnerable land-breeding predators, and 3) the limit should allow for possible unreported krill mortality associated with fishing operations.

Therefore, the Commission adopted a conservation measure and requested that the SC, as a matter of priority, advise the Commission on limits by subarea and, where it considers appropriate, on finer spatial scales.

Squid Resources

The Commission agreed in its 1990 meeting to a standard form for reporting fine-scale catch data; however, there were no reports of squid fishing by any members within the Convention Area during the past year.

Potential New Fishery for Antarctic Crabs

The U.S. received a permit in the 1991 season for an exploratory fishery for king and stone crabs in Statistical Area 48. However, the permit was not used and an application for a new permit was received in July 1991. Because of the 1990 discussions of the SC and the Commission pertaining to new and developing fisheries, the applicant was required to develop and submit a plan for research and data collection that included an environmental-impact assessment of the proposed exploratory crab fishing. A short-term permit was issued, but logistical complications precluded use of the permit prior to its expiration in September 1991. An application for a new permit has not been submitted although the U.S. fisherman is still interested in exploring the Antarctic sometime in the future.

In keeping with the Commission's request concerning advance notification during 1991, the U.S. notified members of its potential new crab fishery and presented the research and data collection plan and environmental impact assessment to the SC for review.

The Commission noted that the process undertaken by the U.S. in developing a plan and assessment for this potential new fishery may provide a useful example of appropriate steps needed to help meet the request for information for setting up new fisheries.

Protection of CCAMLR Ecosystem Monitoring Program Sites

During its 1990 meeting, the Commission adopted a conservation measure which specified the procedure CCAMLR should follow to protect CCAMLR Ecosystem Monitoring Program (CEMP) sites. It was agreed that proposals for site protection should be drafted as specified and brought forward for consideration in turn by the CEMP Working Group (WG-CEMP), the SC, and the Commission.

A draft management plan for protection of the Seal Islands CEMP Site was prepared by the U.S. and reviewed by the WG-CEMP and the SC. The Commission endorsed the recommendations of the two groups and adopted a resolution offering protection to the Seal Islands CEMP Site.

Data Requirements

The U.S. noted that the requirements for data agreed on by the SC and endorsed by the Commission had undergone little change in recent years and yet, in general, there had been a very poor response to these requirements. The Commission should consider the lack of data as a limiting factor in determining management plans.

Observation and Inspection

The SC defined and agreed to a scheme of vessel observation criteria and reviewed the scientific objectives and priorities of this scheme. The Committee recommended that the scheme focus on commercial vessels, identify priorities for allocation of activities among observers, and establish formats for the reports of observers. The Committee recommended that tasks for observers on research vessels not be specified in the scheme.

The European Economic Community (EEC) Delegation stated that they considered the role of observers as defined by the SC, and particularly those related to recording details of catches, was to enforce rather than to gather and validate data. Consensus was not reached, and the Commission agreed to continue discussions at the next meeting. Several members, including the U.S., expressed disappointment that the Commission had not succeeded in establishing a scheme of international scientific observation at this meeting even though the Scientific Committee had agreed upon a scheme of vessel observation.

Conservation Measures

The Commission adopted several Conservation measures:

1. To minimize the incidental mortality of seabirds in the course of longline fishing, procedures were established for setting longlines to reduce seabird mortality.

2. Beginning in the 1995 fishing season, the use of cables to monitor trawl nets is prohibited.

3. The definition of a new fishery was established, and members will henceforth be required to notify the Commission of the intention to start a new fishery not less than three months in advance of the next regular meeting of the Commission.

4. A precautionary catch limit on *Euphausia superba* of 1.5 million t was established in Statistical Area 48. This limit shall be allocated to subareas if the total catch reaches 620,000 t.

5. It is prohibited to conduct a directed fishery on *C. gunnari* in Statistical subarea 48.3 during the 1992 season.

6. It is prohibited to conduct a directed fishery during the 1992 season on *Notothenia gibberifrons, C. aceratus, Pseudochaenichthys georgianus, N. squamifrons,* and *Patagonotothen guntheri* in Statistical subarea 48.3.

7. A catch limit of 3,500 t during the 1992 season was established for *D. eleginoides* in Statistical Subarea 48.3.

8. A catch limit of 245,000 t during the 1992 season was established for *E. carlsbergi* in Statistical subarea 48.3.

9. It is prohibited to fish for all finfish in Statistical subarea 48.1 during the 1992 season.

10. It is prohibited to fish for all finfish in Statistical subarea 48.2 during the 1992 season.

11. It is prohibited to conduct directed fishing for *N. squamifrons* in Statistical divisions 58.4.4 (Ob and Lena Banks) during the 1992 season.

Cooperation With Other International Organizations

At the 43rd Annual Meeting of the International Whaling Commission (IWC), CCAMLR was represented as an observer for the United States. The U.S. reported to CCAMLR on the IWC meeting concerning the assessment of whale stocks, management procedures, scientific permits, and the International Decade of Cetacean Research. Rennie Holt served as the IWC observer to the CCAMLR SC and Commission meetings. He will provide the IWC with a report of items of interest to IWC. (J. Rosenberg, FTS 893-5600)

COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

COASTAL EASTERN PACIFIC POPULATION BIOLOGY OF FISHES

Dover Sole Induced to Spawn in Captivity

Dover sole have been induced to spawn in captivity; the eggs and larvae have been reared past first feeding. The Coastal Fisheries Resources Division (CFRD) has been attempting to spawn Dover sole, *Microstomus pacificus,* in the laboratory to answer a number of questions concerning their life history. The pelagic larval and juvenile stages of Dover sole appear to be extremely slow growing, and juveniles can remain in the upper layers of the ocean for periods greater than one year. This protracted larval stage is atypical of flatfishes. Although this extended development must influence larval dispersal patterns and may affect recruitment success, the ecological and physiological reasons for this life-history strategy are completely unknown.

In an effort to better estimate the age of different developmental stages of field-caught plankton samples and to calibrate the egg-production method (EPM) estimates of biomass, members of the CFRD are interested in studying the spawning and development of Dover sole in captivity. There is very little information on the techniques for spawning deep-water fishes so the effects of factors such as day length on maturation are unknown. Although the effects of day length on a fish that spawns at 800-1,000 m might be considered negligible, the Atlantic halibut, *Hippoglossus hippoglossus,* which also spawns in deep water, does mature in response to day-length changes.

Fish that were originally captured off Morro Bay in the spring of 1990 and maintained in the laboratory were placed on a varied diet, with controlled water quality, and were exposed to a controlled day-length regime beginning in November 1990. Two females examined during a routine survey in early July contained large (1.4 mm), but unhydrated, eggs. One female was left to mature naturally, if possible, and the second was treated with the hormone LHRH to induce final maturation. Both females hydrated. Hydrated eggs were recovered from the spawning tanks but were infertile. Both females were then anesthetized and manually stripped of eggs. Eggs were immediately mixed with milt that had also been artificially stripped. Eggs from the naturally maturing female did not develop but those from the hormone-treated female had high rates of fertilization and hatching. This hormone-treated female has spawned two more times and remains in good health.

Dover sole spawn at depths where temperatures range 4-6 °C, but the eggs float up to warmer (8-12 °C) surface waters where development proceeds. This makes the estimates of development times that are used for the EPM uncertain. To resolve this, eggs spawned at 5 °C were either kept at 5 °C or raised in increments of 0.2 °C or 0.4 °C over the course of 48 hours to either 8 or 12 °C respectively. The biologists felt this simulated the natural ascent of the buoyant eggs to the

surface. Eggs reared in this way hatched in 15 days at 12°C, 23 days at 8°C and 40 days at 5°C. Interestingly, larval hatch rates and development were better at the two warmer temperatures rather than at the spawning temperature. Larvae at 12°C lived for 75 days and attained a length of 13 mm (Figure 1). Larvae successfully made the transition from yolked to first feeding larvae and moved from rotifers to *Artemia* nauplii. They were offered

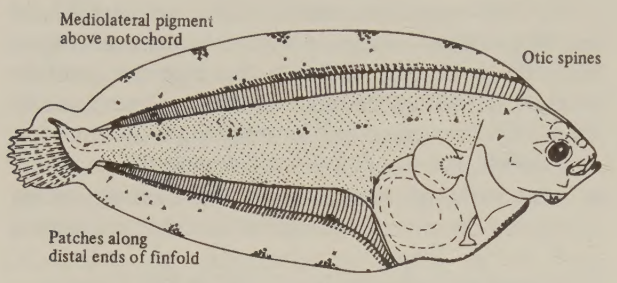


Figure 1. *Microstomus pacificus* larvae at 15.0 mm SL. Illustration from Matarese et al., Laboratory Guide to Early Life History Stages on Northeast Pacific Fishes. NOAA Tech. Rep. NMFS #80.

copepods, but the remaining larvae did not make the transition to this larger food. The main source of mortality was from samplings taken to document the different growth stages. Larry Robertson and Eric Lynn have been directly responsible for the spawning and rearing experiments; Geoffrey Moser and N. Chyan-huei Lo are now studying the preserved material to refine the staging of eggs and improve the EPM parameters. Further experiments are planned in an attempt to rear juvenile Dover sole to study the physiological adaptations of these slow-growing larvae and the later stages of juvenile development. (R. Vetter, FTS 893-7125)

SURVEY SYSTEMS DEVELOPMENT AND EVALUATION

Comparison of Trawl Catch and Remotely Operated Vehicle Line Transect Surveys

As a part of the project to develop habitat-specific stock assessment methods for west coast demersal fisheries resources, replicate trawls and Remotely Operated Vehicle (ROV) line transects have been conducted in Monterey Bay. Bottom trawls with a poly-Aberdeen trawl have been conducted on smooth bottoms at depths of 100, 200, 400, 600, 800, 1,000, 1,200 and 1,400 m on two cruises taken in April and September of 1991. To date, ROV transects have concentrated on 200, 400, and 600 m sites to obtain replicates for gear comparison.

Analysis of data from the 600 m ROV surveys indicates that line- transect methods are most appropriate. The number of fish observed declines more or less continuously with distance from the midline of the image (distance is expressed in lanes from the middle) (Figure 2). If the numbers observed were constant in lanes 1-7 and declined from 8-14, then strip-transect methods would be appropriate.

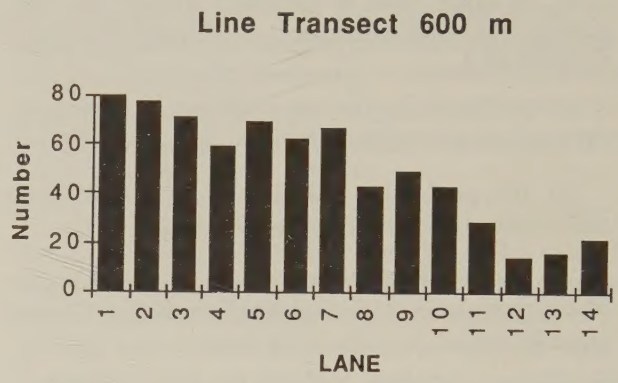


Figure 2. The number of fish observed in three line transects at 600 m. Each paired lane is parallel to the center line of the transect. Lane number 1 on either side of the center line and line number 14 represents the two lanes farthest from the center line.

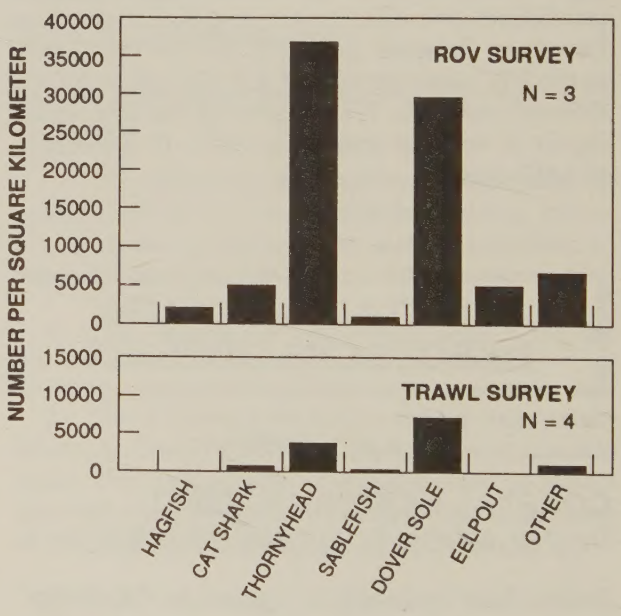


Figure 3. Densities of demersal fishes observed at the same 600 m site using two different methods. Densities from the remotely operated vehicle (ROV) survey were estimated using line-transect methods. Densities from the trawl survey were estimated using the trawl swept-area method.

The tendency for more fish to be observed in the center of the image may be due to the illumination of the sea floor or to fish responding to the ROV. Some species respond to the ROV more than others. About 46 percent of catsharks (Family Scylinorhinidae) observed respond to the ROV, and these appear to be swimming away as they enter the field of view. Other fish such as thornyheads, *Sebastolobus* spp., (14 percent) and Dover sole, *Microstomus pacificus*, (4.5 percent) respond less and do not react until in the field of view.

Comparison of the densities from the ROV and from the trawl indicate that more fish are observed with the ROV than are collected with the trawl (Figure 3). No hagfish were collected by the trawl, but the video transects indicate 1900 hagfish per sq. km. Sablefish densities observed by the ROV are 3 times, Dover sole 4 times, thornyheads 9 times, and eelpouts 80 times the densities derived from trawl data. These differences are probably due to escapement through the meshes or under the footrope of the poly-Aberdeen trawl. (J. Butler; FTS 893-7149)

COMMERCIAL AND RECREATIONAL FISHERIES RESEARCH FOR MANAGEMENT (CFRFRM)

Bioeconomics of Northern Anchovy

Jon M. Conrad (Summer Faculty Fellow, CFRFRM Program, Coastal Fisheries Resource Division [CFRD]) completed an Administrative Report titled "A bioeconomic analysis of the northern anchovy" (LJ-91-26). Copies are available from Larry Jacobson.

Bathymetric Demography of Dover Sole

Bathymetry is a key element in the demography of Dover sole, *Microstomus pacificus*. Juvenile Dover sole begin life in relatively shallow water on the continental shelf but move gradually down the continental slope into deeper water as they grow and reach sexual maturity. Large and old individuals may eventually reach depths greater than 1,500 m. The ontogenetic migration of Dover sole into deeper water gives rise to a general pattern of increasing size with depth, but there are differences between the sexes and locations. To describe these patterns in greater detail, Larry Jacobson and John Hunter computed probability distributions for depth, length, and sex using research trawl data for Dover sole taken off central California and Oregon. Results indicate that females live at greater depths than males, that abundance of large Dover sole may be lower at depths where minimum oxygen concentrations occur and that major differences in bathymetric demography exist between study sites, which they suggest are due to differences in bottom topography (Figures 4-6). Jacobson and Hunter used one group of probability distributions and logbook data for Oregon and central California in a simple model to demonstrate how depth of fishing and bathymetric demography complicate interpretation of length composition and other data from a commercial fishery. Results from the model indicate that depth-stratified assessment models may be required to interpret fisheries data for Dover sole and other species, like shortspine thornyhead, (*Sebastolobus alascanus*), and sablefish, (*Anoplopoma fimbria*), that undergo ontogenetic migration from shallow into deep water. (L. Jacobson, FTS 893-7117)

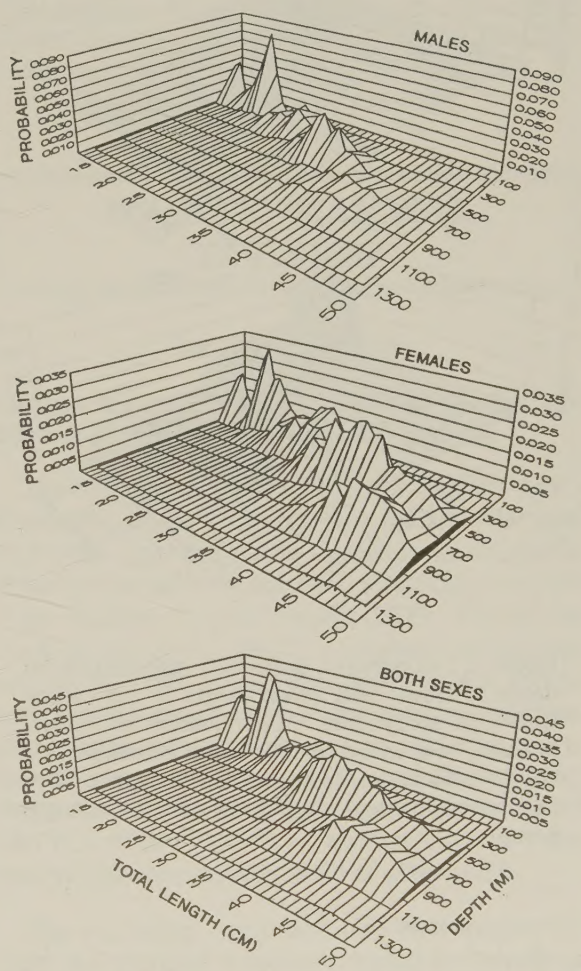


Figure 4. Joint probability distributions for depth and length of Dover sole in the central California study area based on bathymetric data and research trawl surveys conducted from January to February, 1987 and from February to April, 1988. Distributions for males, females, and males and females combined are shown in the upper, middle and lower panels.

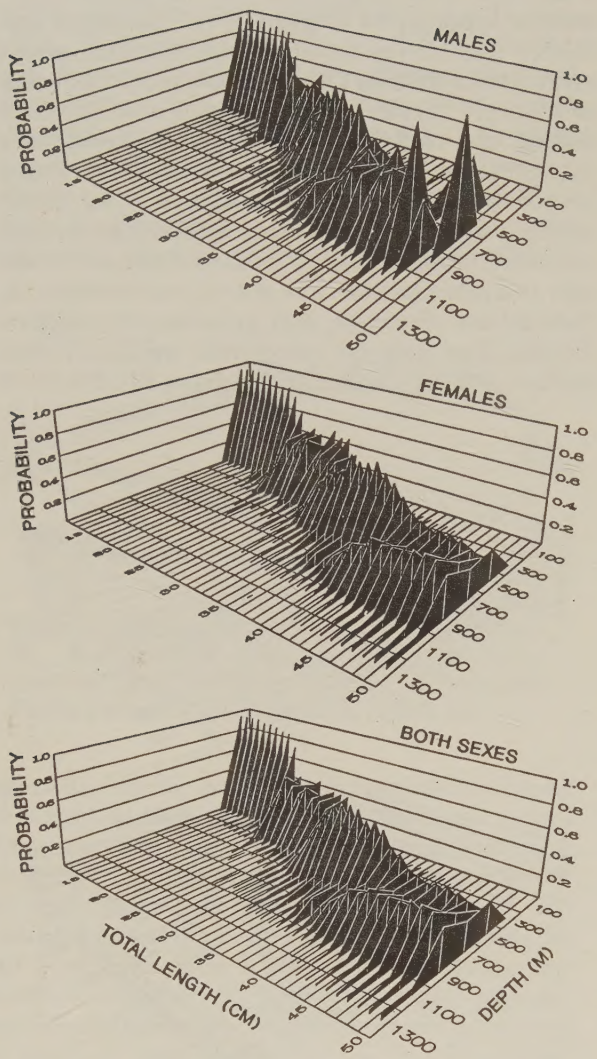
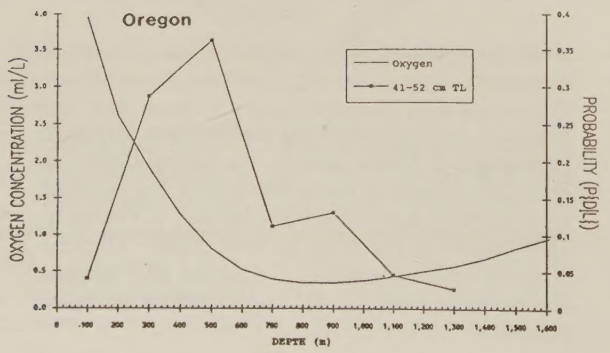


Figure 5. Conditional probability distributions for depth of Dover sole given length in the central California study area. Distributions for males, females, and males and females combined are shown in the upper, middle and lower panels. Conditional distributions are given for each 1-cm length group.



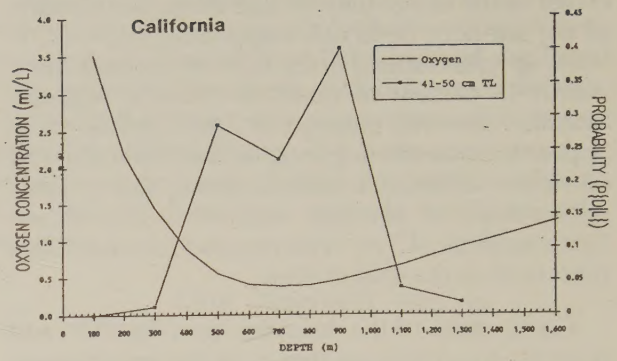


Figure 6. Oxygen concentration (milligrams L^{-1}) as a function of depth in the Oregon and central California study areas and probabilities for depth of Dover sole larger than 40 cm TL. Oxygen data were obtained from an atlas and are means for observations recorded from January to December, 1920-1970 (Churgin and Halminski 1974).

Survey of U.S. Anglers Who Fish in Mexican Waters

With the assistance of the Southwest Fisheries Science Center, the Mexican Department of Fisheries (MDF) is conducting a mail survey of U.S. anglers who purchase a license to fish in Mexican waters. MDF sells three types of angler licenses: 1) day licenses for one-day or overnight trips made from commercial passenger fishing vessels (CPFV's) departing from San Diego, 2) excursion licenses for multiple-day trips made from CPFV's departing from San Diego, and 3) weekly, monthly, and annual licenses that cover all types of boat-based fishing. Three different questionnaires corresponding to the three types of licenses have been designed and pretested and are being mailed to a systematically-drawn sample of license applicants. Each of the survey instruments is about ten pages long and includes questions about participation, catch rates, expenditures and angler demographics.

The survey is targeted for individuals who purchase a Mexican fishing license during calendar year 1991. Thus far, MDF has received over 1,400 completed questionnaires, corresponding to a response rate of 60%. A report summarizing the survey results will be completed by the summer of 1992. (C. Thomson, FTS 893-7116)

West Coast Fishing Fleet Cost-Earnings Data Base Updated

Industry Economists Jeff Lee, Dale Squires, and Sam Herrick have recently updated the west coast

fishing fleet Cost-Earnings Data Base (CEDB). The CEDB was created in 1988 by combining data from the PACFIN Research Data Base (RDB) with data from the National Marine Fisheries Service's (NMFS) fishing vessel Capital Construction Fund (CCF). This data base has become invaluable in supporting economic research and providing economic information on selected U.S. west coast fisheries.

The RDB is the major source of landings and exvessel earnings data for individual west coast fishing vessels. It contains landings, exvessel prices and fishing vessel characteristics data for Washington, Oregon, and California vessels for the years 1981 through 1990. These data are routinely collected by the individual states through fish ticket and vessel registration programs and provided annually to the Southwest Fisheries Science Center for processing and inclusion in the RDB. Because of its design, comprehensiveness, continuity, and the level of support provided to users, the RDB has become extremely useful to researchers investigating and monitoring changes in fishing activities, gross earnings, and physical characteristics of west coast fleets over time.

The CCF is a program through which U.S. fishermen are able to set aside tax-deferred income for the purchase, construction or reconstruction of U.S.-built fishing vessels. As part of the program, participants must provide annual federal tax forms for their fishing operations. These are the source of the vessel cost data. Costs associated with fishing are the costs of owning and operating a vessel. Costs related to the vessel's operation are referred to as variable costs because they increase or decrease depending on the level of operation. Costs categorized as fixed costs are those that are incurred whether or not fishing effort is expended. Because not all fishermen participate in the CCF, cost data are sample data assumed to be representative of vessels active in each of the fisheries contained in the CEDB.

CEDB cost data for the west coast vessels participating in the CCF are combined with their landings, revenue and physical characteristics data from the RDB. The data base has been used extensively in analyses of fisheries management measures proposed by the Pacific Fisheries Management Council, in measuring and monitoring the productivity of the west coast groundfish fleet and the U.S. tropical tuna purse seine fleet, and in formulating an economic model of the Pacific coast groundfish fishery.

The original CEDB consisted of cost-earnings data for vessels participating in the Pacific coast groundfish, tropical tuna and California gillnet fisheries. Represented are 60 west coast groundfish trawlers operating over the 1981-1986 period, or 171 vessel-year observations. The original CEDB also contained 40 vessel-year observations for tropical tuna purse seiners and 39 vessel-years for California gillnetters. The updated CEDB has an additional 171 vessel-year observations for 60 groundfish trawlers over the years 1984-1989. Twenty-five of these vessels are new to the data base. In June 1991, there were 21 tropical tuna purse seine fleet observations added to the CEDB, but no new gillnet fleet observations. Newly added were cost-earnings data for a sample of vessels participating in west coast fisheries for anchovy, mackerel and sardines for the years 1984-1989. (S. Herrick, FTS 893-7111; D. Squires, FTS 893-7113; J. Lee, FTS 893-7114)

MARINE MAMMAL DIVISION

La Jolla, California

Marine Mammal Division Prepares for the Status of Porpoise Stocks Workshop

The National Marine Fisheries Service has a legislative mandate under the Marine Mammal Protection Act to report to Congress on the results of the Service's 5-year dolphin monitoring program in the Eastern Tropical Pacific (ETP). During the week of November 18-22, workshop participants will review background documents which will be used to create the final report required by Congress. Workshop participants are to include representatives from the Marine Mammal Commission, Inter-American Tropical Tuna Commission (IATTC), NMFS scientists, academics, and other recognized experts in the field of assessment.

The workshop, separated into two special sessions, is scheduled to focus on trends in abundance and stock identification of ETP dolphins. The Biological Assessment Program, the Dolphin Stock Assessment Program, the Dolphin Ecology Program, and the Fishery-Independent Assessment Program have joined efforts along with the Senior Scientist Division and the staff of the IATTC to produce 20 documents for review during the workshop. Many of the papers have been submitted for publication and the rest are currently

available as NMFS Administrative Reports. A final Status of Porpoise Stocks report should be completed by the end of 1991. (J. Sisson, FTS 893-7964)

DOLPHIN STOCK ASSESSMENT PROGRAM

The Dolphin Stock Assessment Program is to present three papers for the status workshop dealing with dolphin population abundance estimation. One paper, by Program Leader Tim Gerrodette, uses a cross-validation approach to assess several methods of adjusting research vessel observer estimates of dolphin school size compared with accurate counts of 171 dolphin schools based on high-quality aerial photographs. For 10 of out 23 observers, estimates of school size were improved by calibrating against schools of known size. For the other 13, estimates were not so improved. A weighted mean of the observers' calibrated estimates provided the best combined estimate of school size, based on minimum squared error. Overall, Gerrodette found that dolphin school size was accurately estimated by observers on research vessels although there was considerable variability in the estimates.

Another paper, co-authored by Wildlife Biologist Paul Wade and Gerrodette and presented to the International Whaling Commission in 1991, analyzes five years (1986-1990) of abundance data collected during the monitoring of porpoise stocks research vessel surveys in the eastern tropical Pacific. Their paper presents a stratified analysis which gives estimates of relative abundance of nine stocks of the four target species (spotted, spinner, striped, and common dolphins), using line transect methods. They found no significant trends in population size for any dolphin stock during 1986-1990 although the statistical power of detecting trends was low.

Wade has also been involved in conducting an assessment of the status of the eastern spinner dolphin stock in the ETP. In the third paper, he used current estimates of abundance from research vessel surveys in combination with estimates of mortality from tuna vessel observer data to estimate the pre-exploitation or historical population size for the eastern spinner stock, using the back-calculation technique (SWFSC Administrative Report LJ-91-12). A range of values was used for the current population size, for the maximum net recruitment rate (MNPL), for z (the shape parameter that sets maximum net productivity level), and for the number of animals killed relative to the estimated mortality. He found that relative population sizes (current population size divided by historical population size) ranged from 0.18 to 0.73. In most cases, relative population size was well below MNPL. His results, indicating that the stock of eastern spinner dolphins is probably depleted, will be discussed fully during the Status of Stocks Workshop. (T. Gerrodette, FTS 893-7131; P. Wade, FTS 893-7097)

BIOLOGY ASSESSMENT PROGRAM

Sue Chivers will present three papers at the Status of Porpoise Stocks Workshop. In the first paper, co-authored with Doug DeMaster (SWFSC Administrative Report LJ-91-29), she tests a variety of life-history parameters as potential biological indices of population status (size relative to carrying capacity) for the four target species in the eastern tropical Pacific (ETP). The compensatory response model for predicting biological indices was not consistently supported by the species and stocks analyzed. The second paper, co-authored with Andrea Bright (SWFSC Administrative Report LJ-91-30), analyzed post-natal growth rates of northern and southern stocks of the offshore spotted dolphin. The third paper, co-authored with Al Myrick (SWFSC Administrative Report LJ-91-31), tested for trends and stock differences in the age at sexual maturity (ASM) for northern and southern offshore spotted dolphins. No trends in growth rates or ASM were detected, but there were significant differences between the northern and southern offshore spotted dolphin samples. (S. Chivers, FTS 893-7093)

PHOTOGRAMMETRY PROGRAM

Wayne Perryman and Morgan Lynn will present at the Porpoise Status Workshop the results of their analysis of aerial photographs identifying geographic forms of common dolphins. They have found at least four morphologically-distinct geographic forms in the ETP. They have compared length data for common dolphins from northern, central, and southern regions and have found significant differences in average length for adult animals and for "adult females," which are defined as animals accompanied by a calf. Analysis of back-calculated birth dates demonstrated differences in timing of reproduction between the geographically adjacent forms. Perryman and Lynn compared length distributions from aerial photographs and from samples collected during purse seine fishing operations and found striking similarities providing support for the validity of each. Their work demonstrates a new, non-invasive method for obtaining unbiased life history and morphological data. (W. Perryman, FTS 893-7014)

ETP ECOLOGY PROGRAM

Steve Reilly and Paul Fiedler will present two papers which analyze the interannual variability in dolphin habitats in the ETP. In the first paper, they use a canonical correspondence analysis which is an eigenvector ordination technique, including direct gradient analysis, to investigate habitat use by the four target dolphin species in the ETP during 1986-1989. These data were collected during the annual monitoring of porpoise stocks research vessel surveys. The second paper also presents the results of a canonical correspondence analysis of data from research vessel surveys and tuna vessel sightings. Fiedler and Reilly discuss ways that environmental data could be used to reduce bias in dolphin abundance estimates based on Tuna Vessel Observer Data (TVOD). (S. Reilly, FTS 893-7164)

FISHERY-DEPENDENT ASSESSMENT PROGRAM

Elizabeth Edwards and Peter Perkins will present their paper on the statistical power of detecting trends in dolphin abundance, using tuna vessel observer data from 1975-1989. They used a weighted linear regression to calculate 5-, 8-, and 10-year series of abundance indices for eight stocks of the four target species in the ETP. Edwards and Perkins found that detecting relatively small linear trends in dolphin abundance using TVOD and standard weighted linear regression techniques was not feasible except, perhaps, for northern spotted dolphins. They support the recent approach used by the IATTC, which incorporates a more versatile, curvilinear, smoothing method. (E. Edwards, FTS 893-7099)

HONOLULU LABORATORY

Honolulu, Hawaii

INSULAR RESOURCES INVESTIGATION

New Method Developed for Estimating Mortality and Growth of Larval Fishes

A new approach for obtaining unbiased estimates of mortality and growth parameters from length-frequency data biased by the size selectivity of sampling gear--the inverse method for mortality and growth estimation (IMMAGE)--was recently developed by Fishery Biologists David Somerton and Donald Kobayashi. The preferential targeting of animals of a certain length by most sampling gear is unavoidable because of mechanical constraints (e.g., mesh size) or animal behavior (e.g., swimming ability). This is generally undesirable for scientific purposes since an accurate estimate of the size-age distribution of the underlying population is needed to make accurate parameter estimates for that population. In the case of plankton nets, typically smaller and larger larval fishes are under-represented in the catch data. Some small individuals are extruded through the net, and some large individuals avoid the net altogether. Analysis of such catch data will result in biased estimates of growth and mortality.

Traditionally, one of two approaches is used to alleviate bias in the catch data; both approaches were evaluated by Somerton and Kobayashi with a Monte-Carlo computer simulation using a simple situation where only gear avoidance occurs. The first approach is to correct the length distribution if the length-specific capture probabilities are known. For example, if two individuals of a certain length are caught and the gear is known to catch only 5% of the individuals of that length in its path (i.e., a 0.05 probability of capture), then the observed number of captured individuals (N=2) can be divided by 0.05. In this example, 40 individuals "should" have been caught if the net retained everything in its path. However, this approach can cause consistent underestimates of mortality. The division by small-capture probabilities can generate unusually high numbers of individuals at the larger lengths; this in turn exerts considerable influence on the least squares catch-curve regression (log numbers at age versus age) used to estimate mortality. Such bias is essentially due to magnification of sampling variability.

The second approach is to simply truncate data that are suspected of being underrepresented in the catch. Opposite to the first approach, this can cause a consistent overestimate of mortality. Truncation is ineffective because **any** truncation by length will cause an underestimate of one or more of the cohorts' number at age (as some individuals of an age cohort are lost), which then biases the regression estimate of mortality.

IMMAGE differs from traditional approaches because the sequence of calculations is backwards; hence, "inverse." For example, in the first traditional approach, the observed catch (Figure 1a) is corrected by dividing by the probability of capture values; this yields a reconstructed population (Figure 1b) which is mapped into an age distribution

Figure 1.Comparison of the bias-correction and IMMAGE approaches to estimating instantaneous mortality rate (M) from selection-biased length-frequency data. Bias correction (left column) begins by dividing (a), the observed length-frequency distribution, by estimates of capture probability to estimate (b), the unbiased length distribution. The unbiased length distribution is then converted to (c), an age distribution, and *M* is estimated with (d) linear regression. IMMAGE (right column) begins by creating (e), an unbiased age distribution using initial estimates of *M* and the number of day 0 larvae, N_0. The unbiased age distribution is converted to (f), an unbiased length distribution using the ageing sample. The unbiased length distribution is multiplied by the capture probabilities (g) to estimate the sampled length distribution (solid line); then, mortality estimates are varied iteratively to minimize the residual sum of squares between the observed (histogram) and the estimated length distributions.

(Figure 1c). Mortality is then estimated in the catch-curve regression (Figure 1d). In contrast, IMMAGE starts with a simulated age distribution constructed with a trial value for mortality (Figure 1e). This age distribution is mapped into a population length distribution (Figure 1f) and then is scaled by the probability of capture values; the result is a simulated catch (solid line, Figure 1g) which can be compared to the observed catch (bars, Figure 1g). Using iterative nonlinear least squares, the mortality estimate can be continually improved until the best fit is achieved between the simulated and observed catch. Since the capture probabilities are used multiplicatively on the simulated population, the sampling variability in the observed catch is not magnified and all the observed catch data are used, thereby eliminating any bias due to over- or under-estimated cohort sizes as in the traditional approaches.

IMMAGE was evaluated against the traditional approaches using Monte-Carlo computer simulation and was shown to consistently outperform them by producing mortality estimates that were free of bias and less variable. Similarly, IMMAGE estimates of growth were unbiased. IMMAGE is extremely adaptable in terms of growth model specification, mortality schedule, and gear-selection curve. Perhaps more importantly, it can be easily modified to estimate length-dependent mortality, which may be more realistic than simple constant or age-dependent mortality.

A paper recently submitted to *Fishery Bulletin* describes the development and Monte-Carlo evaluation of IMMAGE: "Inverse method for mortality and growth estimation: A new method for larval fishes." A forthcoming paper will describe the results obtained with IMMAGE when used to estimate seasonal growth and mortality of larval anchovies, *Encrasicholina purpurea*, in Pearl Harbor. (D. Kobayashi (808) 943-1242)

Paper Estimates Growth and Production of Biomass-Dominant Fishes on a Southern Californian Artificial Reef

Edward DeMartini, leader of the Insular Ecology Study, presented a paper at the Fifth International Conference on Artificial Habitats for Fisheries held in Long Beach, California, November 3-7, 1991, entitled "Growth and production estimates for biomass-dominant fishes on a southern Californian artificial reef." This paper presents estimates made from May to November 1989 of the somatic growth and somatic and gonadal production for six species that comprise most of the standing crop biomass of the fishes on Torrey Pines Artificial Reef #2 (TPAR). TPAR is a shallow (10- to 15-m deep), quarry rock artificial reef, 14 years old, off La Jolla, California.

Growth was estimated from weight-converted length increments of 142 Floy-tagged individuals at liberty for a median of 187 days. Egg production was estimated for females of three taxa (four species) as the product of the weight of batch egg production and spawning frequency (the latter determined from histological evidence of day-old postovulatory follicles). Milt production was deduced from male to female ratios of gonad weights for reproductive fish.

Somatic growth rates varied three- to fourfold among the six species and, in part, reflected the distribution of maturity stages of intraspecific populations. On the average, per capita growth rates of taxa dominated by immature stages were faster than those dominated by large adults. Somatic production varied more than somatic growth rates (by a factor of 15) because of additional variations in standing stock biomass among populations. The somatic production of at least one species was underestimated as the result of a tag effect on growth.

Weight-specific egg production varied only twofold among the three taxa examined, perhaps because fishes with smaller batch egg productions compensated by spawning more frequently and vice versa. Estimates of weight-specific milt production further diverged because of the influence of relative testis-to-ovary weights that ranged from a small fraction to unity. Additional variation among taxa in total gonadal (egg plus milt) production was about one-half of somatic production (a factor of eight). Besides representing interspecific differences in adult biomass, variations in gonadal production reflected intraspecific differences in the biomass contributions of the two sexes within the fraction of adults that were reproductively active.

Despite likely substantial underestimates of gametic materials, gonadal production ranged from a large fraction to a large multiple of somatic production among the four species. These observations suggest that the elaboration of tissue unrelated to yield is nontrivial and that it represents a major component of energy flow through the fishes in this reef system and perhaps in other reef systems as well.

DeMartini's paper, co-authored with Arthur Barnett, Thomas Johnson, and Richard Ambrose, will be considered for publication in the *Bulletin of*

Marine Science issue dedicated to the conference proceedings. The Saltonstall-Kennedy Program funded the study which was conducted during the time DeMartini served as technical director for MEC Analytical Systems Inc., in Carlsbad, California. (E. DeMartini (808) 943-1266)

FISHERIES OCEANOGRAPHY RESEARCH PROGRAM

Distribution of Tuna Larvae near Oahu

George Boehlert, leader of the Fisheries Oceanography Research Program, and Bruce Mundy, fishery biologist, recently described the distribution of tuna larvae (Scombridae) near Oahu, Hawaii, in an SWFSC Administrative Report. This is the first study of scombrid larvae using nets that sample discrete depth strata rapidly while simultaneously measuring hydrographic variables.

Fish larvae were collected with a 1 m^2 multiple opening-closing net and environmental sensing system (MOCNESS) and 0.49 m neuston net during four cruises (September and December 1985 and April and June 1986). The MOCNESS contains eight opening-closing nets on a single frame as well as conductivity-temperature-depth sensors which measure water temperature, salinity, net depth, and volume of water filtered as plankton are collected.

On each cruise, fish larvae were collected day and night at stations 1, 5, and 15 nmi off leeward Oahu and 2, 5, and 15 nmi off windward Oahu. At the inshore stations of each transect, samples were taken in eight depth strata (0-80 m); at the two offshore stations of each transect, samples were taken in nine strata (0-200 m).

Different genera had distinct patterns of offshore distribution (Figure 2). *Thunnus* larvae were often most abundant at the nearshore station of the leeward transect; most of those large enough to be identified specifically were *T. albacares* (ahi or yellowfin tuna). Densities (number of larvae/1,000 m^3 water sampled) of *T. albacares* larvae at the nearshore, leeward station were often an order of magnitude greater than elsewhere. In contrast, larvae of *Katsuwonus pelamis* (aku or skipjack tuna) were usually most abundant at the two offshore stations of each transect. Larvae of *Auxis* spp. (keo keo or bullet and frigate mackerels) showed no consistent onshore-offshore pattern. Although nearshore concentrations of *Thunnus* larvae have been reported in earlier studies by others in Oahu and French Polynesia, the importance of nearshore areas as tuna nurseries is unknown. The abundance of *Thunnus* larvae in the limited nearshore area needs to be compared to that in the vast offshore area, and the survival of larvae in each area should be evaluated.

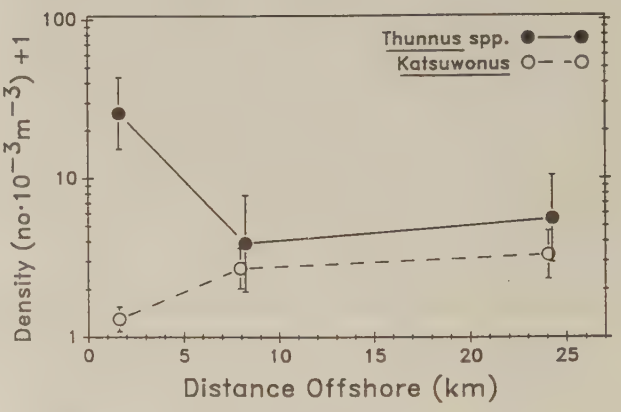


Figure 2. Onshore-offshore patterns of distribution of *Thunnus* spp. and *Katsuwonus pelamis* collected during June 1986 off the leeward coast of Oahu, Hawaii. Values are means from discrete-depth samples taken in the upper 40 m for *Thunnus* spp. (*N*=10 at the nearshore station; *N*=6 at each offshore station) and the upper 80 m for *K. pelamis* (*N*=16 at the nearshore station; *N*=10 at each offshore station). Error bars indicate 1 standard error.

Generic differences in vertical distribution also were found, but all tuna larvae occurred in the upper water column. *Thunnus* larvae were restricted to 0-64 m (most abundant at 0-20 m), *Katsuwonus* larvae were taken at 0-84 m (most abundant at 0-60 m), and *Auxis* larvae were usually found at 0-60 m (often widely distributed at 0-40 m). There was no consistent evidence for diel, vertical migration, except that *Thunnus* larvae were captured in the neuston (0-1 m) at night but not during the day. The strongest diel change was seen in *Auxis* larvae at the nearshore, windward station in April 1986, when larvae were most abundant at 0-10 m during the day and at 50-60 m at night. This change could be explained by the increased mixing of the water (rather than migration) before the night sampling, as suggested by the temperature structure of the water column during these collections. Temperature appears to play an important role in the seasonal and vertical distribution of tuna larvae off Oahu. *Thunnus* larvae were never found in temperatures below 24.2°C, while *Katsuwonus* and *Auxis* larvae were not found at temperatures below 21.8°C.

The report by Boehlert and Mundy provides a detailed data record for further analysis of the pat-

terns observed. Their report contains the first results from a larger study on the vertical distribution of all taxa of fish larvae near Oahu. (B. Mundy (808) 943-1227)

PROTECTED SPECIES INVESTIGATION

The 1991 Field Season in the Northwestern Hawaiian Islands

Field camps were established in 1991 at all five of the major breeding sites of the Hawaiian monk seal, *Monachus schauinslandi*, in the Northwestern Hawaiian Islands. The primary function of the field effort in 1991 was population monitoring because of the large (35%) decline in births at all breeding sites in 1990 (Figure 3). The preliminary data on mean beach counts and number of births in 1991 are in Tables 1 and 2. A brief summary of highlights of the work conducted at each of the camps is provided below.

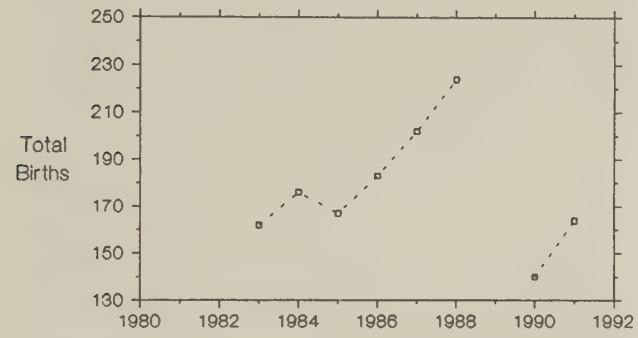


Figure 3. Total number of Hawaiian monk seals born annually.

Kure Atoll

Fieldwork was conducted at Kure Atoll during March 8-August 17 and September 12-18. The mean atoll-wide beach count of seals (Table 1) was significantly higher than in previous years (mean atoll counts, excluding pups, in 1983-90 equaled 19-27 seals). The 14 births observed at Kure Atoll in 1991 are the highest since NMFS research began there in 1981. Thirteen pups survived to weaning and were tagged. One especially-small, weaned female pup was transported to Honolulu for rehabilitation. At least 14 seals were found injured during the field season. Three seals were entangled in debris; two were released and one seal freed itself. Two seals were found with fish hooks (non-commercial fishery) in their mouths; one fish hook was removed and the other fell out within six days. Six weaned female pups (five from Kure and one from Oahu) were maintained in the Head Start Project's enclosure during the summer and were released August 4-13. Six rehabilitated yearling females from the French Frigate Shoals were transported to Kure Atoll and held in the enclosure until they were able to feed independently.

Pearl and Hermes Reef

Field camps were established on Southeast and North Islands at Pearl and Hermes Reef from August 1-September 13. Atoll-wide census showed a mean count of 47 animals, excluding pups, which is a 24% increase over 1990 totals. Births (21) were double the 1990 number. Based on resightings of tagged, marked, or scarred seals, the population at Pearl and Hermes Reef was estimated to be 140-150

Table 1. Mean (non-pup) beach counts.

Island	'83	'84	'85	'86	'87	'88	'89	'90	'91
French Frigate Shoals	--	--	267	284	261	241	268	253	190
Laysan Island	81	78	97	126	133	82	78	74	68
Lisianski Island	86	68	79	94	93	--	--	75	72
Pearl and Hermes Reef	27	31	45	45	36	49	52	38	47
Kure Atoll	22	19	22	26	25	26	27	26	34

Table 2. Number of pups born annually.

Island	'83	'84	'85	'86	'87	'88	'89	'90	'91
French Frigate Shoals	98	106	96	108	121	127	121	89	82
Laysan Island	24	31	32	34	34	45	33	17	33
Lisianski Island	25	16	15	22	19	23	--	17	14
Pearl and Hermes Reef	11	17	19	18	22	21	15	10	21
Kure Atoll	4	6	5	1	6	8	11	7	14

seals, excluding pups. The observed adult male to female sex ratio was 0.8:1. Ten juvenile seals were measured and weighed as part of an immature seal growth study. No serious injuries were observed on any seals; a weaned pup was seen with a neck mark which indicated earlier entanglement. One green turtle died as a result of shark attack.

Lisianski Island

The field camp at Lisianski Island was in operation during June 28-July 30. Both the mean beach count of seals and recorded births remained low (Tables 1 and 2), similar to the numbers reported in 1990. Although the duration of the camp was relatively brief and late in the season, a total of eight seals were observed with large healing back wounds of the type inflicted by adult male seals during mobbings. Most of the victims were adult females. No other major wounds or entanglements of seals were observed.

Laysan Island

A field camp was in place at Laysan Island during March 30-July 30. The mean beach counts in 1991 (Table 1) declined, just as they have for the last 4 years since the peak in 1987. Births (33) were just above average after a record low of 17 births last year. Thirty-one of the pups survived to weaning, and all but one were tagged. Twenty-nine weaned pups, eleven 1-year-olds, and twelve 2-year-olds were weighed and measured as part of the immature seal growth study. The number of females classified as adults increased by 10 since 1990. Four mortalities were documented at Laysan Island; one, a 5-year-old female with a mobbing wound, was killed by a shark. No mobbing incidents were observed, but 19 seals with mobbing injuries were seen, resulting in the death described above and the disappearance and presumed death of three other females. No entanglements of seals were observed.

French Frigate Shoals

Field activities were conducted at French Frigate Shoals from March 28-September 5. The mean non-pup beach count of 190 was significantly lower than in the previous 3 years: 241, 268, and 253 for 1988, 1989, and 1990, respectively. Births continued to decrease from the 1987-89 mean of 123 to 82 in 1991. Of the pups born, 69 survived to weaning, 13 died or disappeared prior to weaning, and 5 died post-weaning. Five undersized, weaned female pups were collected and transported to Sea Life Park on Oahu for rehabilitation. A total of 143 seal injuries were recorded during the year, 2 of which were caused by embedded longline fishing hooks. A piece of fishing net that had cut into the neck of an adult female and a loop of line around an adult male were both removed. A subadult male was found dead, probably from hyperthermia, behind the seawall at Tern Island. Weight, length, and girth data were collected on a total of 119 young seals, including weaned pups and 1- and 2-year-olds, for the immature growth study.

Necker Island, Nihoa, and Gardner Pinnacles

Necker Island, Nihoa, and Gardner Pinnacles have small populations of monk seals and are not included in the Protected Species Investigation's usual monitoring schedule; however, transport to these islands in 1991 was provided by the Fish and Wildlife Service, enabling a low-cost check of these populations.

Field observations were conducted at Nihoa during August 17-23. The mean beach count was 26.7 seals (excluding pups), the highest documented at this site and nearly twice the mean count of the mid-1980s. Seven pups were seen at Nihoa; four were weaned and tagged. Two seals with mobbing injuries were observed. Necker Island was visited briefly on August 18. The single census included 30 seals, excluding pups. This count was similar to the mean count in the 1980s (27.8 for 1983-88). Only one nursing male pup was observed. Two adult seals were hauled out at Gardner Pinnacles on August 20.

Eight French Frigate Shoals-tagged seals were seen at Nihoa and five at Necker Island. Some of these seals had not been seen for 3 years. No tagged seals were sighted at Gardner Pinnacles.

No mortalities were documented at Necker Island, Nihoa, and Gardner Pinnacles. No entanglements of Hawaiian monk seals or turtles were observed. (W. Gilmartin (808) 943-1239)

WESTERN PACIFIC FISHERY INFORMATION NETWORK (WPACFIN)

Major Data System Upgrades Implemented

During September 1991, staff of the Honolulu Laboratory's WPACFIN traveled to fisheries offices in American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands (CNMI) to install new software and train local staff in its use. As of October 1, 1991, virtually all fisheries data processing by central WPACFIN, the American

Samoa Department of Fish and Wildlife, the Guam Department of Commerce, and the CNMI Division of Fish and Wildlife is being accomplished via dBASE IV applications that have been provided or supported by WPACFIN. For over 2 years, the WPACFIN program has been assisting island fisheries agencies in meeting the demands for more sophisticated data reporting and analysis capabilities, primarily by upgrading their data processing systems to IBM-compatible computers and by developing dBASE IV database applications.

Created in 1981, WPACFIN is an intergovernmental cooperative program of fisheries agencies in the western Pacific, whose major goal is to provide timely and accurate information for Federal fisheries management and planning. The principal participating agencies are the NMFS, the Western Pacific Regional Fishery Management Council (WPRFMC), and the local governmental fisheries agencies in Hawaii, American Samoa, Guam, and the CNMI. Within the Honolulu Laboratory, the WPACFIN program is responsible for coordinating activities required to implement and operate the microcomputer-based network and to centralize data provided by the various agencies.

As a result of the WPACFIN staff's recent work, new or modified versions of 11 menu-driven, user-friendly integrated processing systems have now been implemented in the fisheries offices in American Samoa, Guam, and the CNMI. These applications include systems for processing data for commercial landings (trip tickets), offshore and inshore creel surveys (port sampling surveys), vessel inventory and classification, fishing tournaments, fishery imports, and longline fishery transshipments. Although some of these systems are not yet 100% complete and none is fully documented, they currently contain nearly 600 dBASE IV programs totaling almost 150,000 lines of code and most options and modules are fully functional. Each of these systems contains modules for all major data processing functions from data entry, edit, and quality control through data summarization, report generation, and numerous file-management options. Several other major processing systems are also under development by the WPACFIN staff, including several analytical systems to assist the island agencies in preparing annual reports for the WPRFMC's fishery management plan monitoring teams.

As part of the WPACFIN program's continuing effort to improve data systems in the region, a significant accomplishment made during October linked direct telecommunication between computers in the central WPACFIN office and in the American Samoa and CNMI fisheries offices. This was possible using new hardware and software installed by the WPACFIN staff in September. Even though the maximum transmission rate obtainable on the initial linkups was a disappointing 1,200 BAUD, software upgrades and system modifications now made immediately available to these fisheries offices through electronic transfers are a substantial improvement in the daily operating and maintenance capabilities of WPACFIN. Remote troubleshooting of local data bases, software, and hardware problems will also be enhanced by use of this new communication capability. Similar telecommunication links are also planned for the near future for the Guam Department of Commerce, Guam Division of Aquatic and Wildlife Resources, and the Hawaii Division of Aquatic Resources. Methods for increasing the transmission rate to a maximum of 9,600 BAUD will be investigated in the future to keep communication costs to a minimum. This new computer-to-computer communication capability can also be used for real-time data access and transfer in the event that in-season fisheries management becomes necessary in the western Pacific region. (D. Hamm (808) 943-1214)

PACIFIC FISHERIES ENVIRONMENTAL GROUP

Monterey, California

Optimal Environmental Window and Pelagic Fish Reproductive Strategy in Upwelling Areas

As a contribution to the Climate and Eastern Ocean Systems (CEOS) study underway at PFEG, visiting scientists Philippe Cury and Claude Roy of the Institut Francais de Recherche Scientifique pour le Developpement en Cooperation (ORSTOM), Paris, France, presented a paper entitled " Optimal environmental window and pelagic fish reproductive strategy in upwelling areas" at the International Symposium on Benguela Trophic Functioning: Resource Utilization from an Ecosystem Perspective held in Cape Town, South Africa September 8-13, 1991. Their co-author for this paper was

Souad Kifani of Institut Scientifique des Peches Marocaines (ISPM), Casablanca, Morocco.

Recruitment Variability

Many attempts have been made to correlate abundance of larvae or pelagic fish recruitment with environmental fluctuations in upwelling areas. The relationships between upwelling intensity and recruitment appear to be sometimes negatively and sometimes positively correlated. These contradictory results question the existence of a unified theory relating upwelling intensity and recruitment. The comparison of geographically-distinct upwelling areas and their effects upon different pelagic species suggests that these correlations may be valid by reinforcing the idea that, in an Ekman-type upwelling, a dome-shaped relationship exists between recruitment success and upwelling intensity. Recruitment success increases with upwelling intensity in areas where wind is low or moderate; food availability then becomes the limiting factor. Recruitment success decreases with upwelling intensity in areas of strong wind where physical constraints such as turbulence or offshore transport are the main determinants of larvae mortality rates. The existence of an "optimal environmental window" for pelagic fish recruitment success associated with wind speed values of 5-6 $m \cdot s^{-1}$, previously described by Cury and Roy (1989), was discussed. New examples using the Moroccan sardine (*Sardina pilchardus*) and the Californian anchovy (*Engraulis mordax*) were used for this discussion, and new results of the effect of wind on larvae survival were presented.

In wind-generated upwelling, vertical advection, new input of nutrients, offshore transport, and wind-generated turbulence are positively correlated with wind speed. Increasing upwelling intensity from weak to moderate should have a positive effect on recruitment since increased primary production would enhance food availability. Strong upwelling should have a negative effect on recruitment because wind mixing or offshore transport are high even if the primary production increases. The theoretical relationship between recruitment variability and annual upwelling indices is assumed to be dome shaped (Figure 1). The nonlinearity of the curve is explained by considering two classes of limiting factors: trophic and hydrodynamic. On the left side of the curve, the limiting factor is the production of food due to the low intensity of the upwelling; on the right side of the curve, the upwelling is strong and wind mixing or turbulence are the limiting factors. Consequently, an "optimal environmental window" exists for moderate upwellings where the effects of the limiting factors are minimized (Figure 1).

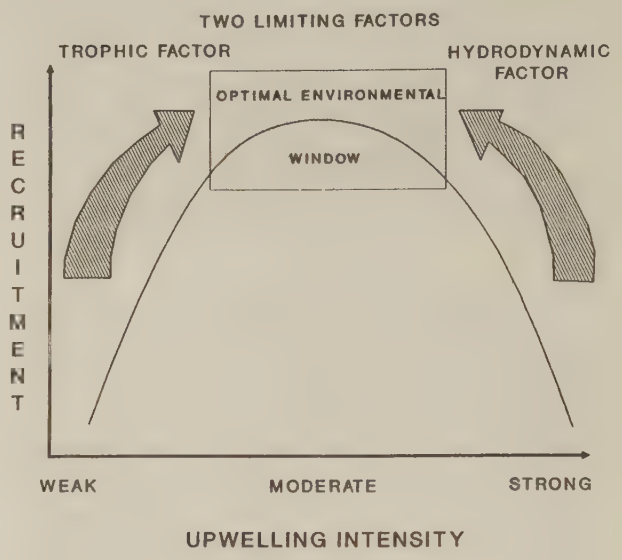


Figure 1. Theoretical relationship between recruitment and environmental factors in upwelling areas (from Cury and Roy, 1989).

Reproductive Strategy

Using a comparative approach between the west African upwelling areas, spatial and temporal reproductive dynamics of coastal pelagic fish were investigated. Different patterns in the timing of reproductive activity emerged. In areas where wind intensity is low or moderate (Senegal and Ivory Coast), upwelling and reproductive activity are in phase; in areas where wind intensity is strong, reproductive activity is out of phase with the upwelling season (Morocco and Sahara) (Figure 2). A possible explanation is proposed, accounting for these contradictory patterns but which differs slightly from previous analyses where offshore transport is described as one of the main detrimental factors. From the observed patterns along the west African coast, the timing of reproduction is set to minimize the effects of the two limiting factors defined by the "optimal environmental window." Cury and Roy hypothesize that these patterns are the response, from an evolutionary point of view, of a long-term reproductive adaptation to the environment that maximizes recruitment success. The reproductive strategy of coastal pelagic fish may have evolved in order to adjust to the "optimal environmental window" by investing most of the reproductive effort when the effect of the limiting factors, food availability and wind-generated turbulence or offshore transport are both minimized.

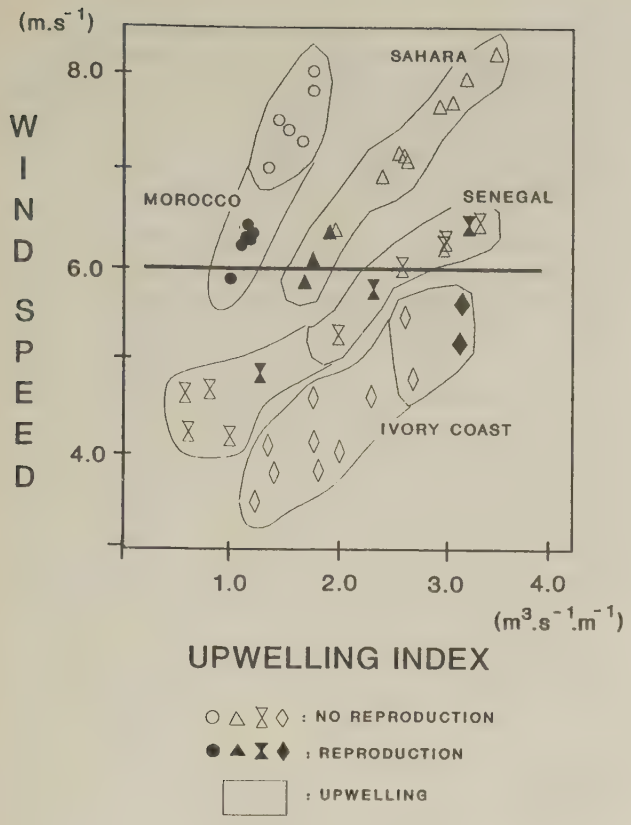


Figure 2. Mean annual cycles of monthly wind speed (m/s) and of upwelling indices ($m^3 \cdot s^{-1} \cdot min$ the main west African reproductive areas (Morocco, Sahara, Senegal, and Ivory Coast). The bold figures represent the months when reproduction is active (from Roy, 1990).

For future work on pelagic fish reproductive strategies, Cury and Roy believe it will be of great interest to analyze the seasonal response of reproductive activity to climatic changes in upwelling areas. These clues will help us understand the resilience or instability of pelagic fish populations facing short-term or long-term climatic changes. A dome-shaped relationship between recruitment success and environment may also explain long-term population changes in areas where upwelling intensity increases or decreases consistently through time. Bakun (1990, 1991) recently presented evidence that intensification of coastal ocean upwelling has occurred in the main upwelling areas of the world. The consequences, according to the theoretical dome-shaped relationship, would be a decrease in fish production in most of the studied areas. Adaptability of reproductive strategies that may or may not be able to buffer the increased upwelling intensities is a key question for the future. (P. Cury and C. Roy, (408) 646-3311)

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

PELAGIC ECOSYSTEM MODEL DEVELOPMENT PROGRAM

Fishery Parameters Estimated from Tag Recapture Data

In previous issues of the Report of Activities of the Southwest Fisheries Science Center, progress was reported on the development of a method of analyzing fisheries from tag recapture data by the use of causal Green functions, or propagators, of the field equations that represent tag and untagged fish dynamics. Operations Research Analyst Carlos Salvadó now reports an exact solution to the integral equation for the effort-independent propagator and an estimation technique for tagged and untagged fish parameters, using the moments of the propagators that are consistent with an optimal fit of the observed data.

In the propagator approach to modeling tag dynamics,

$$g_0(\mathbf{r}, t|\mathbf{r}_0, t_0) = \frac{c_T(\mathbf{r}, t)}{f\#_T}$$

is the effort-dependent probability density of finding a tag at location $\mathbf{r}$, at time t if at an earlier time t_0, it was at $\mathbf{r}_0$, $c_T(\mathbf{r},t)$ is the tag catch rate density, $f=qe$ is the death rate due to fishing, and $\#_T$ is the number of tags released at $(\mathbf{r}_0,t_0)$. The effort-independent probability density $g(\mathbf{r},t \mid \mathbf{r}_0,t_0)$ of finding a tag at location $\mathbf{r}$, at time t, if at an earlier time t_0, it was at $\mathbf{r}_0$, can be computed from

$$g(\mathbf{r}, t|\mathbf{r}_0, t_0) = g_0(\mathbf{r}, t|\mathbf{r}_0, t_0)$$

$$+(\frac{1}{\#_T}) \int_{T_0} dt' \int_{\mathcal{A}} dS' g(\mathbf{r}, t|\mathbf{r}', t') c_T(\mathbf{r}', t')$$

where A is the area of the fishery and T_0 is the time interval $[t_0,t]$. For an arbitrary single time interval $T_j=[t_{j+1},t_j]$ the solution to the integral equation relating g and g_0 is given by

$$g(\mathbf{r}, t_{j+1}|\mathbf{r}_0, t_j) = g_0(\mathbf{r}, t_{j+1}|\mathbf{r}_0, t_j)$$

$$+E_N(t_{j+1})\mathcal{T}_j \int_{\mathcal{A}} dS' g_0(\mathbf{r}, t_{j+1}|\mathbf{r}', t_j) c^T(\mathbf{r}', t_j)\,,$$

where

$$E_N(t_{j+1}) = \left[\#_T - \mathcal{T}_j \int_A dS'' c^T(\mathbf{r}'', t_j)\right]^{-1}$$

and $t_j \geq t_0$. If the number of time intervals is m, the above solution has to be applied m times to generate g from knowledge of g_0. This cuts the amount of computation time. In the alternative way of generating g from g_0, if n is the number of fishing areas in the fishery, it takes the inversion of n linear equations $n \bullet m$ times.

Once the effort-independent propagator is constructed, it can be used to evaluate fish parameters. The skipjack fishery in the Eastern Tropical Atlantic off western equatorial Africa was considered. The effective sizes of the fishing areas were calculated as well as the distances from the tag release points to the centers of the fishing zones. It was assumed that all tagged and untagged fish parameters were constant. Using the asymptotic properties of the propagator, which were reported in the May-June 1991 Report of Activities of the Southwest Fisheries Science Center, the following parameters were estimated: the estimated advective speed is between 10 and 20 nautical miles per month while the average diffusive speed is estimated to be between 150 and 200 nautical miles per month. Natural death rate (natural mortality) is estimated between 5 and 10% per month while the death rate due to fishing (fishing mortality) is estimated at about 0.5% per month. These are in agreement with a previous analysis, reported in the September-October 1990 issue of the Report of Activities, which optimally estimated the fish stock parameters. However, the technique of estimating stock parameters reported here requires much less software development and execution time. (C. Salvadó, FTS 893-7052)

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

Billfish Tagging Cooperators in the Pacific

The Southwest Fisheries Science Center's marine game fish-tagging program utilizes cooperating individuals and marine game fish organizations as distribution points for billfish tagging equipment. The major distribution points for tagging striped marlin off southern California are the Balboa Angling Club, Newport Beach, CA; Catalina Seafood; The Tuna Club, Avalon, Catalina Island, CA; and the San Diego Marlin Club, San Diego, CA. In the north central Pacific area, the Pacific Ocean Research Foundation (formerly Pacific Gamefish Foundation), Honolulu, HI, is the major distribution point for the Hawaiian Islands. Distribution of tagging equipment in the southcentral Pacific is through the cooperation of Alan Ellacott of the Hauia Club de Tahiti, located in Papeete, Tahiti, French Polynesia.

Within the past two years, there has been an increased interest in the tagging of blue marlin, and occasionally striped marlin, around the island of Guam. As a result, a new cooperator has been added resulting in a distribution point in the western Pacific. Fishery Biologist Gretchen R. Grimm of the Department of Agriculture, Division of Aquatic and Wildlife Resources, Agana, Guam, is the cooperator.

In addition to the locations where tagging equipment is available, it is distributed to many billfish anglers and charterboat operators in Mexico, Central America, and to such locations as Hong Kong, Singapore, and Kenya in the Indian Ocean. (J. Squire, Jr. FTS 893-7072)

Spawning of Albacore in the South Pacific Ocean

Fishery Biologist Darlene Ramon completed a preliminary report on spawning seasonality of albacore, *Thunnus alalunga*, in the South Pacific Ocean for the fourth South Pacific Albacore Research Workshop held November 4-8 in Taiwan. The project was initiated to examine the spawning seasonality of albacore in the South Pacific and the relationship of maturity-to-length modes of fish being caught in the surface fishery, which was begun in November 1989. The project is being conducted jointly by the Tuna and Billfish Assessment Programme (TBAP), the South Pacific Commission (SPC) and the Southwest Fisheries Science Center (SWFSC). The project is designed to provide a better understanding of the reproductive biology of albacore in the South Pacific, an understanding that could contribute to informed management decisions.

The South Pacific Commission provided gonad samples from 101 fish sampled between January 1990 and April 1991. Samples were collected by a port sampler from frozen albacore landed at Noumea, New Caledonia. The fish were caught in New Caledonia and adjacent waters. Samples were also collected during the same period onboard the M/V *Lofa*, a longline vessel operating off Tonga.

The samples were analyzed for reproductive status based upon gross morphology and micro-

scopic examination. The presence of late-developing oocytes rather than mature oocytes has been used as an indicator of spawning in albacore because mature-stage albacore are not available to the fishery. Either mature fish move out of the region, cease to feed and be caught by hook while in spawning condition, or the albacore's ovarian development rapidly progresses from late development to the ripe and spent stages.

Oocyte diameters were used as an indicator of the maturity stage of the ovary. No ripe or advanced-staged ovaries were found in the samples. During the austral winter months, the samples contained immature oocytes with the largest mode centered at 0.1 mm. Oocyte diameter rapidly increased between September and November, from 0.1 mm to 0.6 mm (Figure 1) and progressed from the inactive/immature stage to the late-developing stage.

The average ovary weight was low during the austral winter months (Figure 2). The weight increased through the southern spring and summer when spawning takes place. The main spawning season in the South Pacific is from September through March with peaks between November and February.

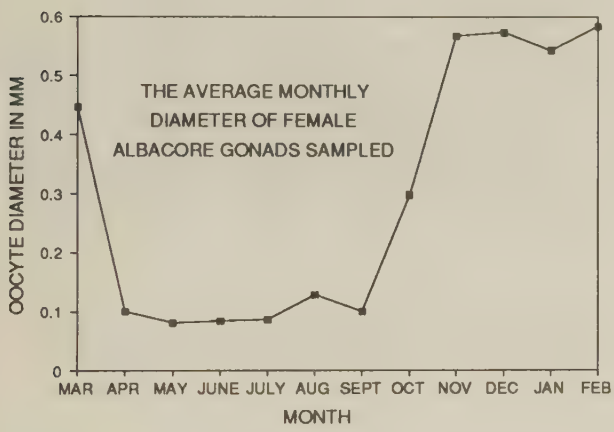


Figure 1. The average monthly weight of female albacore gonads sampled in the South Pacific.

Albacore have asynchronous ovaries, and they contain ooyctes in all stages of development during their spawning season. Fish which have asynchronous ovaries are considered to have multiple spawnings over an extended period. Since albacore have a protracted spawning season, it is difficult to determine the length of the spawning season or the number of spawnings per season.

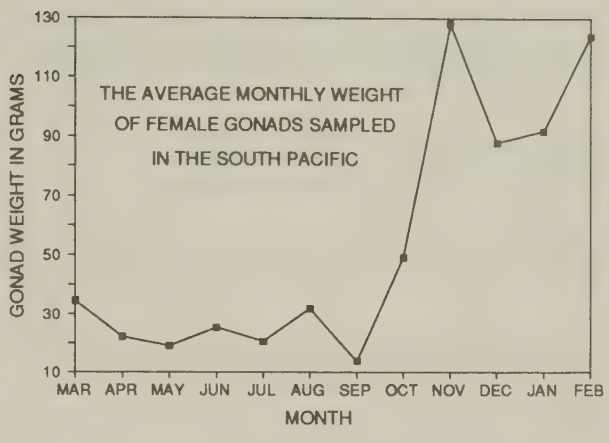


Figure 2. The average monthly oocyte diameter of female albacore gonads sampled in the South Pacific.

Data suggest that albacore in the South Pacific spawn during the austral summer months. However, indications of albacore spawning throughout the year in the northern and southern hemispheres have been reported. In previous studies, late-developing ovaries have been found throughout the entire year in the area between 0° and 20°S and 130°W and 160°E. In the zone between 10°S and 20°S, approximately 50% of the ovary samples were staged as late developing in the months of May through September versus nearly 90% in the late-developing stage from November to February. This indicates that some albacore are in spawning condition between May and September, but the majority spawn during the austral summer. The presence of albacore larvae as far north as 20°N during the months of November and April and as far south as 20°S during the months of May through October indicates that spawning occurs throughout the year. Spawning during the winter months may be on a reduced basis and increase during the summer or when albacore cross the equator.

Samples from Tonga and New Caledonia are from the southern albacore spawning region. Consequently, they may not be representative of the albacore spawning condition in the rest of the South Pacific Ocean.

During the second South Pacific Albacore Research (SPAR) meeting, research on the spawning seasonality of albacore and its relationship to the periodicity of length modes in the surface fishery was identified as a priority. To accomplish this, more samples from a greater number of areas and

times are needed. Samples taken near islands are of particular interest since tuna larvae are more abundant in near-reef waters. (D. Ramon, FTS 893-7074)

MULTISPECIES DATA COLLECTION AND EVALUATION PROGRAM

Mexican Tuna/Dolphin Data Manager Given Orientation

Michel Dreyfus, data manager of the recently-created Mexican tuna/dolphin observer program, met with Alan Jackson, fishery biologist, and Ken Wallace, computer programmer/analyst, to acquaint Dreyfus with the tuna/dolphin data-management software and with concepts employed by the Center's Multi-species Data Collection and Evaluation Program. Among other things, Jackson described the observer debriefing and data editing procedures, and Wallace explained the data entry and editing programs. Dreyfus will be headquartered in Ensenada, Mexico, just a two-hour drive south of La Jolla. Jackson is hopeful that this proximity will promote a cooperative and mutually-beneficial relationship between the two data-management programs. (A. Jackson, FTS-893-7048)

U.S. Troll Fishery for Albacore in the South Pacific

Al Coan, mathematical statistician, and Gary Rensink, biological technician, prepared a working paper for the 4th South Pacific Albacore Research (SPAR4) Workshop held November 4-8 in Taiwan. It summarized total catch, sampled catch and logbook effort, and size and estimated age composition of albacore landings from the U.S. troll fishery in the South Pacific during the period 1986-1991.

The U.S. South Pacific troll fishery has grown from two vessels landing 89 metric tons (t) in 1986 to 58 vessels landing 5,984 t in 1991 (Figure 3). The U.S. troll catch represented approximately 10% of the total South Pacific albacore catch in 1990 (Figure 4). The fishing season usually runs November through April.

Overall, approximately 50% of the trips made by U.S. troll vessels have been covered by the voluntary logbook program (65% in recent years). The U.S. troll fishery concentrated its effort south of French Polynesia between 35°S and 45°S latitude and 135°W and 165°W longitude.

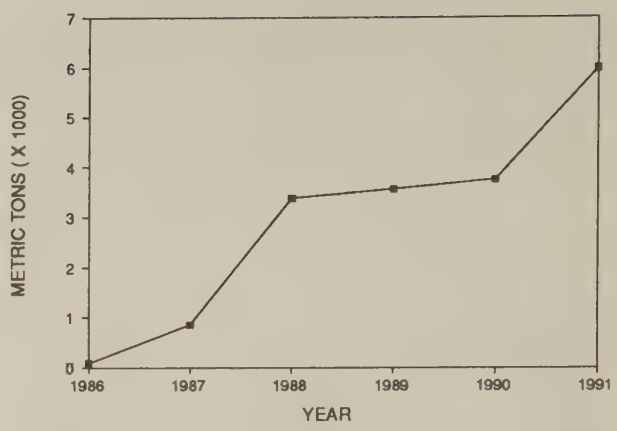


Figure 3. U.S. troll fishery landings in the South Pacific by year.

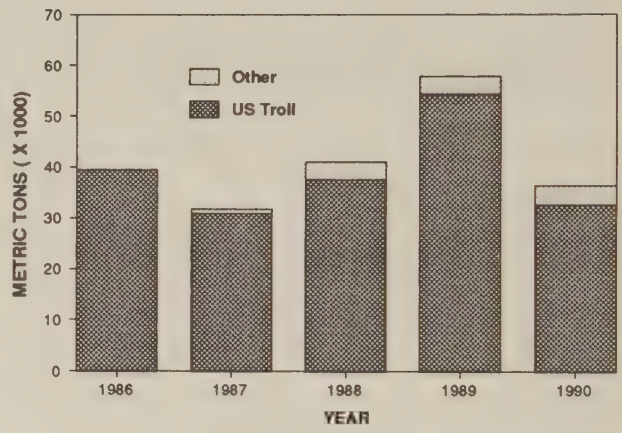


Figure 4. South Pacific albacore landings by year (other fisheries include longline, gillnet and non-U.S. troll).

An index area (described above) and season, January through March, was selected to calculate catch-per-effort (CPE) in metric tons per day fished. Approximately 85% of the catch occurred in the index area/season. CPE in the index area/season reached a high of 2.6 t per day in 1987, declined to 1.8 t per day by 1991, and was always higher than CPE for all areas. CPE in the index area was usually highest in January or February, averaging roughly 2.0 t per day.

Approximately 50 albacore were measured for fork length (tip of snout to fork of tail) from each sampled landing. The majority of the samples were collected in Pago Pago, American Samoa. Overall, more than 70% of the U.S. troll landings have been sampled for size composition (length-frequency).

During the 1989 and 1990 seasons, New Zealand placed observers on some U.S. vessels and sampled the catch.

The sizes of albacore caught during the 1986 to 1991 seasons generally fell into three modes (Figure 5), representing 2-, 3-, and 4-year-old fish. Age-3 fish were dominant with 36% to 62% of the catch, age-2 fish made up 16% to 41% and age-4 fish made up 8% to 25% of the catch. Age groups were easily seen in the size frequencies until 1990 and 1991 when the age groups seemed to merge into one mode (53-93 cm) (Figure 6); this could have been due to the phasing out of gillnet fishing in the area, thus making more fish throughout the size range available to the troll fishery. (G. Rensink, FTS 893-7192)

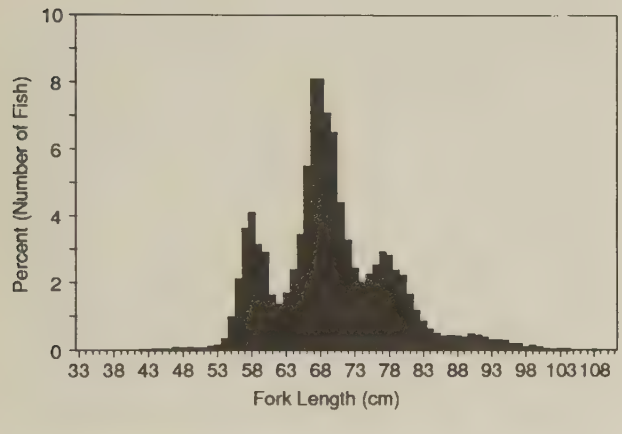


Figure 5. Size composition of albacore caught by the U.S. troll fishery in the South Pacific, 1989.

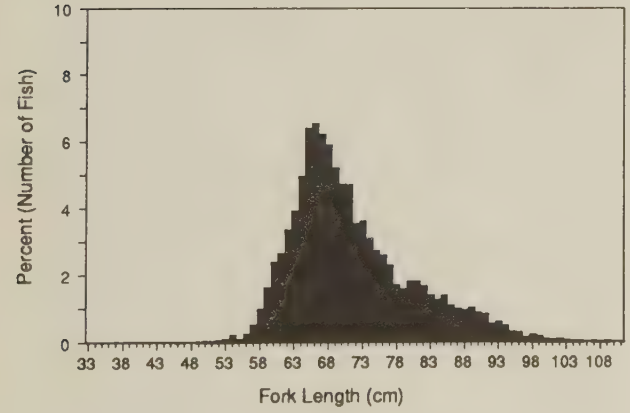


Figure 6. Size composition of albacore caught by the U.S. troll fishery in the South Pacific, 1991.

TIBURON LABORATORY

Tiburon, California

DIRECTOR'S OFFICE RESEARCH

Simulation Model Developed to Evaluate Forecasting Methods for Klamath River Chinook Salmon

Robert Kope has developed a simulation model to evaluate forecasting methods for Klamath River chinook salmon. The model simulates a salmon population in continuous time with commercial and sport ocean troll fisheries, with a river fishery and with spawning escapement. Recruitment is modeled as an autoregressive process with specified mean, standard deviation and autocorrelation. Random variability is also included in growth rates, fishing mortality rates, natural mortality rates, and maturation rates.

The model has been used to evaluate the performance of aggregated indices for forecasting abundance. Age-specific stock forecasts for Klamath River chinook have been inaccurate due to the inability to predict age-3 abundance from age-2 spawners. Various schemes to forecast aggregate stock abundance by multiple regression on combinations of components of the spawning run and the ocean fisheries were compared to the current method of forecasting each age class from the spawning run of the previous year. The criterion for evaluating the forecasting methods was correlation with actual abundance of the simulated population.

So far, results indicate that aggregated forecasts do not perform as well as the age-specific forecasts when there is no autocorrelation in recruitment. As autocorrelation in recruitment increases, the performance of the aggregated predictors improves and the performance of the age-specific predictors deteriorates. However, the differences in their ability to forecast abundance are inconsequential. Because the stock comprises about 70 percent of age-3 fish, the inability to forecast age-3 abundance degrades all forecasts. Sensitivity analyses have identified variability in maturation rate for age-2 fish as the single most important factor in limiting the accuracy of forecasts.

Accurate stock forecasts are only required for two purposes: setting quotas for fisheries and deter-

mining whether the minimum escapement goal of 35,000 natural spawners will be met. The Klamath River Technical Advisory Team has recommended to the Klamath Fishery Management Council that they avoid the use of quotas in fishery regulations. Kope plans to further develop the simulation model to evaluate the consequences of the minimum escapement goal relative to the uncertainty in stock projections. (R. Kope FTS 556-0565)

GROUNDFISH COMMUNITIES INVESTIGATION

Unusual Features of Recruitment by *Sebastes* spp. Observed in Northern California Nearshore Habitats during 1991

The yellowtail rockfish, Sebastes flavidus, and the blue rockfish, S. mystinus, have dominated the rockfishes monitored by Ted Hobson, Tony Chess, and Dan Howard of the Groundfish Communities Investigation since 1983 in northern California's nearshore habitats. Assessments were made at two sites about 100 km apart: in Mendocino and to the south in Sonoma. Recruitment during the past seven years has evidenced a pattern (Table 1). Although S. flavidus has tended to be more numerous in the north than in the south and S. mystinus more numerous in the south than in the north, a year of strong (or weak) recruitment for one has been a strong (or weak) year for the other, and that relative level of recruitment has been evident at both sites.

This pattern was disrupted during 1991, however, when sharp differences between the two sites developed. Contrary to previous years, S. flavidus was recruited in much larger numbers in the south than in the north, and while S. mystinus recruits were moderately numerous in the south, their numbers in the north were the lowest since 1983--the year of this century's strongest El Niño. It also may be that the Mendocino value for S. flavidus was inflated somewhat by several large aggregations that may have occurred on the assessment route. As previously noted, when some Sebastes species experience poor recruitment, the relatively few that are present appear to have an increased tendency to aggregate. (E. Hobson, J. Chess, and D. Howard, FTS 556-0565)

Growth and Hatch Dates Determined for Juvenile Lingcod

An unusually large number of pelagic juvenile lingcod (Ophiodon elongatus), 26 to 77 mm standard length (SL) (Figure 1), were taken in a single midwater trawl catch on May 29, 1990, just offshore Point Reyes, California (lat. 38°10'0" N; long. 123°00'3" W). These 230 represented over one quarter of the total of 862 pelagic juvenile lingcod taken in all 678 trawl catches that have been made during the 8 years of the survey (1983-90).

Table 1. Mean number (standard error in parenthesis) of first year juveniles counted/minute off the Mendocino and Sonoma coast during August and September. N=number of one minute assessments.

	1983	1984	1985	1986	1987	1988	1989	1990	1991
MENDOCINO	n=36	n=57	n=50	n=103	n=112	n=62	n=181	n=99	n=80
S. flavidus	0.00	6.58	115.60	6.01	102.66	59.47	1.29	1.93	8.14
	(0.00)	(2.29)	(21.26)	(1.50)	(11.08)	(10.23)	(0.35)	(0.90)	(3.04)
S. mystinus	0.27	1.49	70.56	7.83	181.04	75.89	6.08	0.76	0.64
	(0.09)	(0.30)	(15.32)	(1.88)	(26.19)	(10.18)	(0.94)	(0.17)	(0.16)
Total	0.68	8.38	190.50	23.35	291.67	141.29	10.49	3.53	8.78
	(0.19)	(2.33)	(29.82)	(3.91)	(33.99)	(16.88)	(1.44)	(1.05)	(3.04)
SONOMA		n=57	n=50	n=103	n=112	n=62	n=186	n=100	n=79
S. flavidus		4.39	135.17	6.73	89.39	39.92	1.54	0.12	38.33
		(1.48)	(26.00)	(2.29)	(18.42)	(7.94)	(0.42)	(0.05)	(6.40)
S. mystinus		4.89	117.63	15.27	328.05	175.06	7.19	0.66	13.58
		(1.29)	(19.50)	(3.81)	(52.15)	(16.76)	(0.93)	(0.12)	(1.82)
Total		10.91	257.20	24.97	442.48	221.38	10.39	1.81	51.91
		(2.12)	(35.38)	(5.17)	(66.72)	(22.55)	(1.34)	(0.48)	(7.22)

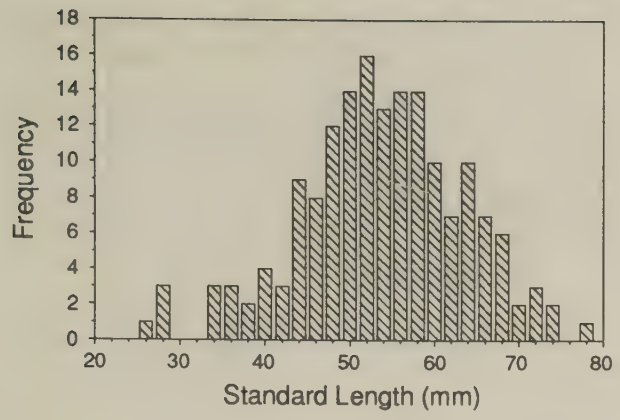


Figure 1. Standard length (SL) frequency distribution of 230 pelagic lingcod caught by midwater trawl just offshore Point Reyes, California, on May 29, 1990.

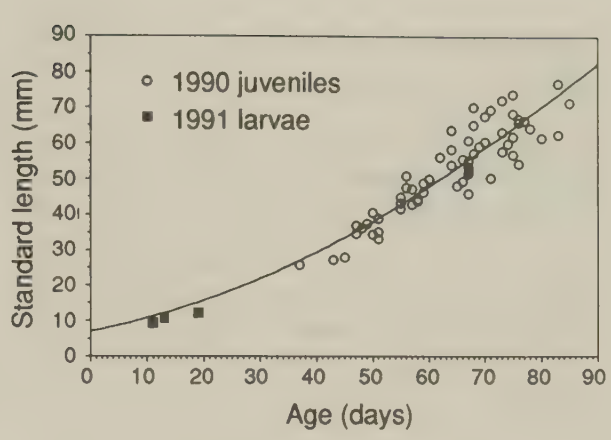


Figure 2. Predicted length (SL) from the log-transformed Gompertz equation as a function of age in days (solid line). The open circle is length versus age data used in the model fit. The solid squares are data from four larvae sampled in 1991, which were not included in the fit.

The 230 lingcod from this single trawl are in contrast with the mean of 0.93 from all other trawls (standard error=0.41). To demonstrate the impact of this catch on a measure of patchiness for number of juvenile lingcod caught, the coefficient of variation increased 31% when it was included, from 6.38 to 8.34.

This extraordinary catch provided a rare opportunity to estimate growth and hatch dates. Daily ages were read from sagittae for a subsample of 63 individuals chosen over a representative size range and, along with SL, were fitted to a log-transformed Gompertz equation,

$$\ln[SL] = \ln[l_o] + k(1\text{-}e^{-gt})$$

where t=age (days) and l_0, k, and g are model parameters. Based upon published estimates of known size at hatch, the intercept term in the final model was fixed at l_0=7.0 mm. The fit of the log-transformed Gompertz equation to the age data was good (Figure 2), with an F=49,778.0, 2,63d.f., and an r^2 value of 0.854. Parameter estimates were $\hat{k}$=3.669 ±0.316 and $\hat{g}$=0.0124 ±0.0016 d^{-1}. Although not included in the model fit, we have included in the figure age data from four larvae sampled in 1991. These points fall on the growth model and suggest that it is also valid for larval lingcod.

The inverse of the fitted growth model ($t=f^{-1}[SL]$) was used as a predictor of the ages of all juvenile lingcod taken in the trawl. The distribution of hatching dates for the fish sampled was estimated

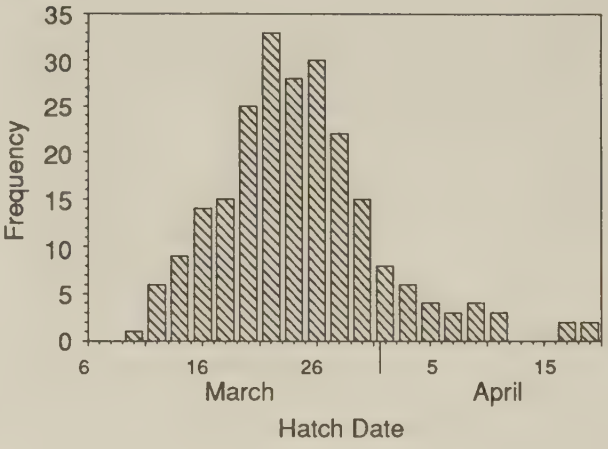


Figure 3. Frequency distribution of hatch dates (age minus date of capture) for all 230 juvenile lingcod from the May 29, 1990, catch.

by subtracting predicted ages from the date of capture. The estimated hatch date distribution for the sample peaked around March 24 and ranged from March 10 to April 19 (Figure 3). The distribution had a wide spread of hatch dates with tails ranging over 40 days. The wide spread of hatch dates confirms that all these lingcod could not have come from a single egg mass. These are the first hatch dates from California known to the Tiburon biologists. (P. Adams, S. Ralston, and T. Laidig, FTS 556-0565)

GROUNDFISH ANALYSIS INVESTIGATION

Spatial Distributions of Ancillary Species Studied with Pelagic Juvenile Rockfish Data base

Since its inception in 1983, the rockfish recruitment program of the Groundfish Analysis Task (GAT) has conducted annual surveys of the abundance of pelagic juvenile young-of-the-year *Sebastes* spp. off central California. Surveys are conducted during May and June, when a series of 35 standard stations are repetitively sampled by midwater trawling in the area between Carmel Bay and Tomales Point. The purpose of the surveys has been to develop a fishery-independent index of prerecruit abundance that is suitable for use in assessments of the trawl fishery for rockfish and to acquire a better understanding of the biological and physical factors that influence rockfish year-class strength.

Pelagic juvenile rockfish represent only a small portion of the many fishes and invertebrates that are regularly sampled on these surveys. Until recently, members of the program had not analyzed the distributional patterns of these ancillary species. However, the spatial distributions of pelagic juvenile lingcod (*Ophiodon elongatus*) and adult plainfin midshipmen (*Porichthys notatus*) have now been summarized from the pelagic juvenile rockfish data base, each revealing a distinctive spatial pattern in abundance (Figure 4 and Figure 5).

Presented in the figures are contoured values of mean catch per 15-minute trawl during May and June. The data were averaged over the last six years of the survey (1986-1991), a time period when three repetitive sweeps of the study area have been conducted. Note that the locations of the 35 standard stations, from which the contour lines were estimated, are shown as filled circles. It is clear that, unlike pelagic juvenile rockfish, both species show a strictly nearshore geographical distribution. Neither is taken off the continental shelf over deep water. Even so, there are clear differences between the species: juvenile lingcod are most abundant in the Gulf of the Farallones, whereas adult midshipmen are most numerous at midshelf locations south

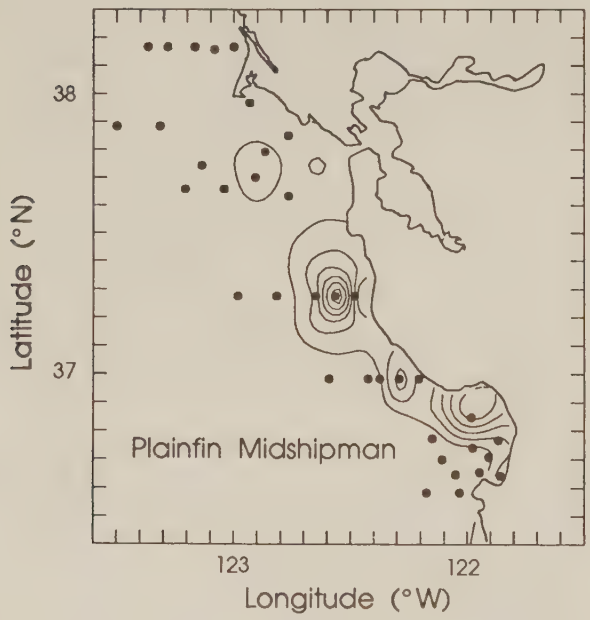


Figure 4. Spatial distribution of pelagic juvenile lingcod sampled with midwater trawl based on 1986-1991 average number caught. Contour lines increase from a low of 1.0 to a high of 6.0 lingcod/trawl; the interval between contour lines is equal to 1.0 lingcod/trawl.

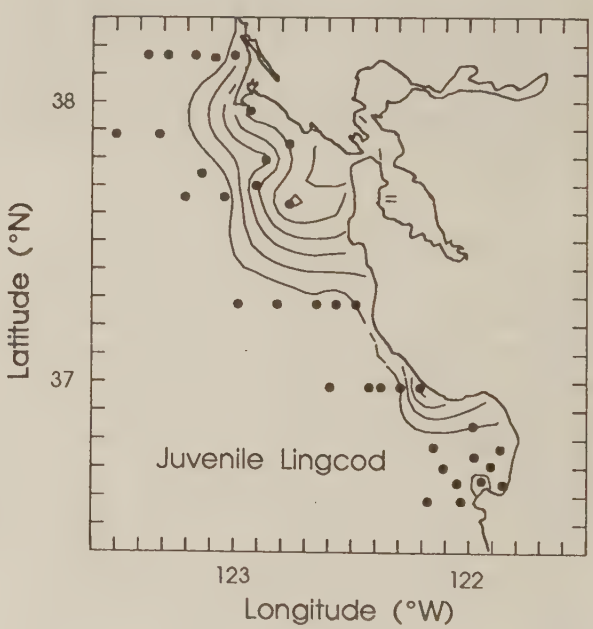


Figure 5. Spatial distribution of adult plainfin midshipmen sampled with midwater trawl based on 1986-1991 average number caught. Contour lines increase from a low of 5.0 to a high of 30.0 midshipmen/trawl; the interval between contour lines is equal to 5.0 midshipmen/trawl.

of the Gulf, especially offshore Pescadero and in the northern portion of Monterey Bay.

Other members of the GAT are now systematically examining the spatial distributions of all the abundant taxa that are quantitatively sampled during these midwater trawl surveys. Results of these analyses will be used, under an interagency agreement with the Environmental Protection Agency, to examine the relative merits of several proposed dump sites for dredge spoils removed from San Francisco Bay. A detailed summary of these findings is expected to be issued as a report by the end of next summer. (S. Ralston, FTS 556-0565)

Identification of Black Dorsal Spot Group of Pelagic Juvenile Rockfish

During the 1991 May-June juvenile rockfish survey aboard the *David Starr Jordan*, pelagic juvenile rockfish were initially identified by species at the time of capture. Species identifications were later confirmed at the Tiburon Laboratory with the aid of a key based upon meristic counts, pigment patterns, and head spination. The pelagic juvenile stages of widow rockfish (*Sebastes entomelas*), yellowtail rockfish (*S. flavidus*), black rockfish (*S. melanops*), and blue rockfish (*S. mystinus*) are morphometrically very similar to one another and are sometimes difficult to identify. These species are often collectively referred to as the "black dorsal spot" group due to the presence of a dark pigment blotch located on the dorsal fin of individuals larger than 35 mm standard length (SL). To determine the difficulty of species identifications of individuals within this group, measurements of seven variables were recorded for 235 widow rockfish, 204 yellowtail rockfish, 43 black rockfish, and 22 blue rockfish. The variables measured fell into several categories: meristic counts (number of dorsal, anal, and pectoral fin rays), the development of preocular and supraocular spines, and pigmentation patterns (on the dorsal fin and at the base of the anal fin). A cluster analysis of these data was performed to determine if these characters alone could be used to accurately identify the four species.

Preliminary results indicate that both blue rockfish and widow rockfish are well separated into distinct clusters, with very little overlap with the other two species (Table 2). Although the majority of yellowtail rockfish separate into another cluster, and the majority of black rockfish segregate into still another, there is considerable overlap between these two species. These findings indicate that blue and widow rockfish are easily identified while the large amount of overlap in the characters used to separate black and yellowtail rockfish make unequivocal identifications for these two species difficult. When specimens of both species are available for comparison, large fish (>35 mm SL) are correctly identified with a high degree of confidence (95%) due to subtle differences in body pigmentation (i.e., black rockfish have a slight greenish tinge and are more uniform in coloration). Identification of small fish (<35 mm SL) is more difficult due to their relatively sparse body pigmentation. (K. Sakuma, FTS 556-0565)

Table 2. Cluster analysis for the black dorsal spot group.

Cluster	Species	Number	% of Cluster Due to Species	% of Species in Cluster
1	Yellowtail	153	95.6	75.0
	Black	7	4.4	16.3
2	Yellowtail	48	57.1	23.5
	Black	36	42.9	83.7
3	Blue	19	95.0	86.4
	Yellowtail	1	5.0	0.5
4	Widow	235	97.9	100.0
	Blue	3	1.3	13.6
	Yellowtail	2	0.8	1.0

GROUNDFISH PHYSIOLOGICAL ECOLOGY INVESTIGATION

Video Surveys of Rockfish Communities

The Physiological Ecology Investigation conducted a hook-and-line and remotely operated vehicle (ROV) survey of rockfish (*Sebastes* spp.) communities at three locations along the central California coast from August 31 to September 6, 1991. The Farallon Islands, Cordell Bank, and Tolo Bank (located just north of Cape Mendocino, California) were studied during the 7-day cruise aboard the NOAA research vessel *David Starr Jordan*. Participating in the cruise were Mark Okihiro from the University of California, Davis; Jan Roletto from the NOAA Gulf of Farallones National Marine Sanctuary; Katy McGauley from Humboldt State University; and Rodney Moore and Mike Hughes from Deep Ocean Engineering. A video survey of the bottom fish community at Cordell Bank was conducted, and approximately 70 minutes of observation of fish activity and associated habitats were recorded. An objective of the video survey was to

identify acoustic images and to compare the observed fish densities and species compositions of the aggregations with hook-and-line catches. Preliminary results indicate that loose rockfish aggregations in boulder-strewn areas, which were detected by the video, were not picked up well acoustically on the chromascope. Hook-and-line catches appeared to accurately reflect visually-observed relative species compositions. The ROV was successfully proven as a useful tool for observing rockfishes in their natural environments. (B. Jarvis, 556-0565)

INFORMATION TECHNOLOGY SERVICES

La Jolla Network to Change from 3+Share to Microsoft LAN Manager

The Center's 3COM LAN has grown significantly over the last year. The user count has increased to over 50 and many new and important network services have been added. Among these is TCP/IP, which is being used by many staff members to provide fast and efficient connections and file transfers with UCSD hosts.

As more people depend on the LAN to perform their jobs, it has become more important to ensure reliable network operation.

ITS has experienced extremely good reliability with both network software and hardware. Downtime has been virtually non-existent. Cabling installations and cable-related problems have been handled efficiently with good results. Monthly deposits of full backup tapes in a secure, off-site location provide an added measure of safety. Daily backups of network disks, stored on-site, provide quick file recovery capability and security.

Email usage has grown substantially. The NMFS SW Regional Office at Terminal Island acquired its own 3COM LAN last year and dynamic Email routing now exists between NMFS staff on Terminal Island and La Jolla. During the year, La Jolla LAN users were polled to identify frequent remote Email usernames. The names of these remote users were subsequently added to our name service, making the "automatic" addressing of Emails to remote users easier and safer (i.e., with 100% naming accuracy). With the addition of our X.25 gateway server, Emails traveling between LANs at NMFS sites now move four times faster. Users have been increasingly enthusiastic about Email.

Due to some surprising news from the 3COM Corporation, the ITS's plan to upgrade the La Jolla LAN to 3COM's version of 3+Open LAN Manager was not completed during the year. 3COM unexpectedly withdrew from the Network Operating Systems marketplace in January 1991. Many 3COM LANs have since begun a migration to Microsoft (MS) LAN Manager Network Operating System. MS LAN Manager very closely resembles 3COM's LAN Manager which was jointly developed with Microsoft.

It is apparent, with 3COM's withdrawal from the LAN operating systems market, that 3+Share and 3+Open LANman have become dead-end products. 3COM has discontinued all developmental work on 3+Share and 3+Open. However, they will continue to sell hardware maintenance for 3COM proprietary servers for the next 5 years.

Both 3COM and Microsoft are encouraging 3COM customers to migrate to Microsoft's LAN Manager by offering heavily-discounted software and technical support in making the conversion. ITS now plans for a 3+Share migration to Microsoft LAN Manager, expected to take place during the first half of 1992.

MS LANman offers important advantages when compared to our current 3+Share network. These include a) better server RAM usage, making the server(s) more powerful and the networks more flexible, b) less memory used on PC workstations for the network software, and c) much faster disk access (highly desirable for multi-user disks). It also offers "named pipes," which are more efficient in a network setting and essential for Client/Server data base packages such as MS SQL Server because they allow the client and server to interconnect and combine data without a total data transfer, thus reducing network traffic. The NMFS LANs in Terminal Island and Honolulu are now running 3+Open, the 3COM version of LAN manager.

Only the 3COM 3S/402 80386, the newer of our two servers, can run LANman. With only a single server running LANman, it is possible that a hardware bottleneck could develop, especially if there is an increase in the running Input/Output-intensive applications, like the FRS and dBASE III+. As a result, the migration to LANman might require the addition of a second LANman server. Depending on an analysis of any bottlenecks that might develop, this server could be configured as a net-

work "file server" (e.g., our present setup) or as an "application specific server" (e.g., an SQL server in a Client/Server environment). (F. Ralston, FTS 893-7062)

PUBLICATIONS

Published

Forney, Karin A., Doyle A. Hanan and Jay Barlow. 1991. Detecting trends in harbor porpoise abundance from aerial surveys using analysis of covariance. Fish. Bull., U.S. 89:367-377.

Aerial surveys designed to detect trends in the abundance of harbor porpoise *Phocoena phocoena* were conducted each autumn, 1986 through 1990. The number of porpoise seen per kilometer of survey effort was used as an index of abundance. Based on these surveys, an analysis of covariance was used to model porpoise abundance. Year was treated as a covariate, and factors which affected sighting rates were included as categorical variables. No significant changes were seen in the abundance of porpoise over the five survey years. Monte Carlo simulations were performed to determine the power of the ANCOVA to detect trends in abundance. We conclude that the ability to detect trends is poor if traditional levels of statistical significance (α=0.05) are used. A larger α-error may be appropriate in the management context of this species. Additional survey years similarly improve the power to detect trends. Based on the results of the simulations, we suggest that power should be defined to include only the detection of the correct trend when two-tailed tests are employed.

Lenarz, William H., Ralph J. Larson and Stephen Ralston. 1991. Depth distributions of late larvae and pelagic juveniles of some fishes of the California Current. Calif. Coop. Oceanic Fish. Invest. Rep. 32:41-46.

The vertical distribution of pelagic young-of-the-year larval and juvenile fishes in the California Current is reviewed. New data from synoptic midwater trawls conducted at depths of 13, 37, and 117 m along the central California coast are presented. Data for 15 species of rockfishes, Dover and rex soles, northern anchovy, and Pacific whiting show that most species tend toward a uniform distribution among the three sampled depths. Notable exceptions include bocaccio (most abundant at 13 m) and blue, yellowtail, and pygmy rockfishes (most abundant at 117 m). With the advent of persistent upwelling during May-June, pelagic juvenile rockfishes tend to occur deeper in the water column than in March-April. Data for shortbelly rockfish support the view that during periods of intense upwelling (May-June), relatively small fish stay deep, presumably to avoid advection offshore. There was not a clear relationship between depth distribution of fish and depth of the thermocline.

McBride, Anne and Joseph E. Hightower. 1991. Predicting sablefish age using otolith characteristics. U. S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-162, 19 p.

Myrick, Jr., Albert C. 1991. Some new and potential uses of dental layers in studying delphinid populations, pp. 251-279. *In*: Karen Pryor and Kenneth S. Norris (eds.), Dolphin societies: Discoveries and puzzles. Univ. California Press, Berkeley and Los Angeles.

Pearson, Donald E., Joseph E. Hightower and Jacqueline T. H. Chan. 1991. Age, growth, and potential yield for shortbelly rockfish *Sebastes jordani*. Fish. Bull., U. S. 89(3):403-409.

Shortbelly rockfish *Sebastes jordani* is an abundant species that could support a large commercial fishery off central California. Prior studies of shortbelly rockfish growth were based on age data obtained from scales or whole otoliths. We show that broken and burnt otoliths provide reliable ages that are substantially different than those derived from previous methods. This new information was used to update estimates of the von Bertalanffy growth curve parameters, the natural mortality rate, and potential yield. We found that shortbelly rockfish live for up to 22 years. Males grew more slowly and reached a smaller maximum size than females. Estimates of natural mortality from three predictive models ranged from 0.212 to 0.378 for males and 0.203 to 0.437 for females. Assuming M is 0.20-0.35 and using biomass estimates from hydroacoustic surveys, we estimated that potential yield in the Ascension Canyon-Farallon Islands area ranges from 13,400 to 23,500 metric tons.

Perrin, William F., Priscilla A. Akin and Jerry V. Kashiwada. 1991. Geographic variation in external morphology of the spinner dolphin *Stenella longirostris* in the eastern Pacific and implications for conservation. Fish. Bull., U.S. 89:411-428.

Variation in color pattern, dorsal fin shape, and body length exhibit sharp north/south gradients centered at about 5-10°N latitude and east/west gradients at about 120-125°W longitude. A conservation zone with boundaries in these regions would provide protection for the morphologically unique eastern spinner dolphin *Stenella longirostris orientalis*. A radial pattern of geographic variation in the eastern Pacific and a complex pattern of discordant variation outside the core range of *S. l. orientalis* suggest that the present separate management of "whitebelly" spinner dolphins (which comprise a broad zone of hybridization/intergradation between *S. l. orientalis* to the east and the pantropical spinner dolphins *S. l. longirostris* to the west and southwest) north and south of the Equator may not be justified on the grounds of conservation of distinct populations.

Polovina, J. J. 1991. Assessment of biological impacts of artificial reefs and FADs. *In*: Indo-Pacific Fishery Commission (IPFC), Proceedings of the Symposium on Artificial Reefs and Fish Aggregating Devices as Tools for the Management and Enhancement of Marine Fishery Resources, Colombo, Sri Lanka, 14-17 May 1990, p. 258-263. Regional Office for Asia and the Pacific (RAPA), Food and Agriculture Organization of the United States, Bangkok.

Polovina, J. J. 1991. A global perspective on artificial reefs and fish aggregating devices. *In*: Indo-Pacific Fishery Commission (IPFC), Proceedings of the Symposium on Artificial Reefs and Fish Aggregating Devices as Tools for the Management and Enhancement of Marine Fishery Resources, Colombo, Sri Lanka, 14-17 May 1990, p. 251-257. Regional Office for Asia and the Pacific (RAPA), Food and Agriculture Organization of the United States, Bangkok.

Smith, M. K., and E. Kostlan. 1991. Estimates of age and growth of ehu, *Etelis carbunculus*, in four regions of the Pacific from density of daily increments in otoliths. Fish. Bull, U.S. 89:461-472.

Growth of the deep slope snapper *Etelis carbunculus* was evaluated from the density of daily increments in sagittal otoliths collected from Hawaii, the Commonwealth of the Northern Marianas [sic] Islands (NMI), French Polynesia, and Vanuatu. The rate of otolith growth (m/day) as a function of otolith radius was fit by regression to a modified Gompertz rate curve and the age of fish estimated by integrating the equation. There were slight regional differences between the estimated values of each of the three otolith growth rate parameters, which may be attributable in part to random sampling differences. However, integrated estimates of fish age versus otolith radius varied little between sites because of the compensatory relationship between two of the three estimated parameters which together determine the rate of dampening of the otolith growth function. There were significant regional differences in average otolith radius, and thus in estimated age, as a function of fish length. Fish from Vanuatu and NMI were younger at a given length than those from the other two regions. However, fish as large as those at Vanuatu are not found at NMI, suggesting there may be regional differences in mortality. Regional age-at-length data were fit to a von Bertalanffy growth curve, both unconstrained and held to a value of asymptotic length (L_∞) obtained from the literature. Estimates of natural mortality for each region are discussed, based on the regional values obtained for the von Bertalanffy growth constant (K). These results should be confirmed using data obtained from a wider range of fish sizes.

Staff, Southwest Fisheries Science Center. Status of Pacific oceanic fishery resources of interest to the USA for 1991. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-165, 85 p.

Sudekum, Anthony E., James D. Parrish, Richard L. Radtke and Stephen Ralston. 1991. Life history and ecology of large jacks in undisturbed, shallow, oceanic communities. Fish. Bull., U. S. 89:493-513.

The large jack species *Caranx ignobilis* and *Caranx melampygus* were collected from the nearly pristine shallow waters of the atolls, reefs, and shoals of the Northwestern Hawaiian Islands. Both species were aged by counting daily otolith increments and validating frequency of otolith deposition by marking captive fish with tetracycline. Growth for each species was well described by a von Bertalanffy relationship. Measured growth of captive *C. melampygus* was also in agreement. Gravid fish of both species were found only in April-November; peak spawning season for both was about May-August. Reproduction began at ~350 mm SL (~2 years old) in *C. melampygus* and at ~600 mm SL (~3-1/2 years old) in *C. ignobilis*. Fecundity of female *C. melampygus* varied approximately as the 1.7 power of body weight. Both species were 90% piscivorous, as judged from combined volume and number of prey and incidence of predation. Crustaceans and cephalopods comprised several percent of the diet of *C. ignobilis*; both groups were present but less important in *C. melampygus*. Both jack species ate gastropods in trace amounts. The overall diet of the two species showed moderate overlap: "Pianka's" index of overlap, A_{yz}= 0.42. The rate of food consumption for captive *C. melampygus* was used to estimate the respiratory metabolic coefficient, which in turn was used to estimate respiratory demands for all size-classes of both species. The von Bertalanffy model predicted growth energy, and reproductive energy was estimated from values of the gonadosomatic index. These energy terms were combined to calculate the food consumption required to sustain all size-classes appearing in local catch data. This distribution can be represented by a composite individual for each species consuming a little less than 50 kg/year (*C. melampygus*) and about 150 kg/year (*C. ignobilis*). Rough population estimates indicated that at one well-studied atoll, populations on the two species combined may eat over 30,000 metric tons of prey per year. These results suggest a quantitatively important trophic role for these top-level carangid predators.

Williams, A. B. and R. B. Moffitt. 1991. Crabs from the Mariana Archipelago: *Bothromaia griffini* new genus and species (Brachyura: Majidae), and remarks on *Poupinia hirsuta* Guinot (Homoloidea, Poupiniidae). Proc. Biol. Soc. Wash. 104(3):569-582.

Deepwater trapping in the Mariana Archipelago, western North Pacific Ocean, included incidental catches of a spider crab and a homoloid crab with novel characteristics. *Bothromaia griffini*, new genus and species, family Majidae, subfamily Inachinae, represented by a male and female, seems most closely related to the genus *Pleistacantha* Miers, containing several species distributed in Indo-Pacific waters. The new species resembles members of this genus with

respect to presence of pseudorostral horns, and shape of eyestalks, basal antennal article, epistome, third maxilliped, male sternites and pleopod 1, but differs from them in shape of pseudorostral horns, carapace, male pleopod, and in proportions of the ambulatory legs. Descriptions, illustrations, and comparative discussion are presented. Notes on the homoloid crab, *Poupinia hirsuta* Guinot, include locality data, measurements, remarks on distribution, and discussion of features distinguishing the families of Homoloidea, including a key for their identification.

Woodbury, David and Stephen Ralston. 1991. Interannual variation in growth rates and back-calculated birthdate distributions of pelagic juvenile rockfishes (*Sebastes* spp.) off the central California coast. Fish. Bull., U. S. 89(3):523-533.

Young-of-the-year pelagic juvenile rockfish (genus *Sebastes*) were collected during annual surveys in the spring and early summer, 1983-88, off the central California coast. Growth rates and back-calculated birthdate distributions of five species (shortbelly rockfish *S. jordani*, bocaccio *S. paucispinis*, chilipepper *S. goodei*, widow rockfish *S. flavidus*) were estimated from daily otolith increments.

Interspecific variation in growth rates was evident, with bocaccio exhibiting the fastest growth (0.56-0.97 mm/day) and yellowtail rockfish growing slowest (0.19-0.46 mm/day). Growth rates of all species varied among years. Comparisons of annual growth performance, measured by predicting standard length at a selected standard age, revealed strong positive interannual covariation among the five species studied; in general, growth was relatively good in 1987 and was poor in 1985.

Back-calculated birthdate distributions also revealed strong positive interannual covariation among these species; most distributions were unimodal. The years 1985 and 1988 were characterized by distributions that were centered early in the year; whereas in 1986 (and possibly in 1983) these distributions occurred later.

Approved by Science and Research Director, SWR

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Alheit, Jurgen and Andrew Bakun. Reproductive success of sprat (*Sprattus sprattus*) in German Bight. For consideration for publication in the IOC Workshop Report Series.

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